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PAIN AND DISABILITY OF SHOULDER AND ARM DUE TO HERNIATION OF THE NUCLEUS PULPOSUS OF CERVICAL INTERVERTEBRAL DISKS*

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THE clinical picture of a rupture of an intervertebral disk in the lower lumbar region has become a well-defined entity within the last few years.[1, 2] Its symptoms and signs of root compression are characteristic and easily recognized. The presence and level of the lesion can be demonstrated by lipiodol,[3] which is removed after the x-ray examination.[4] The surgical treatment of what seemed not so long ago to be "intractable sciatica" is gratifying, and the number of cases successfully diagnosed and relieved is increasing steadily.

Herniation of the nucleus pulposus in the cervical region is considered to be rare. Stookey[5] in 1927 described a group of unusual so-called "tumors" arising from the cervical intervertebral disk, and reviewed the subject thirteen years later.[6] He distinguished three different syndromes of cervical-disk herniation: the syndrome of bilateral ventral pressure (3 cases), that of unilateral ventral pressure (3 cases) and that of nerve-root pressure (1 case). In the majority of his cases, and in those reported by Mixter and Ayer[7] and other observers,[8, 9] the herniated cartilage produced compression of the cord. This led to the belief that the symptomatologies of disk herniation in the cervical and in the lumbar region are fundamentally different. Stookey also concluded from his observations that the operative results in cervical herniations are not too encouraging.

There is evidence that cord compression as a diagnostic criterion of cervical herniation has been overemphasized. In our experience lesions of cervical disks produced compression of the cord in 6 cases, and involvement of nerve roots was the predominant feature in 8 cases. Stookey described the picture of root compression as consisting of muscle atrophy and hypotonia, limited to the distribution of the roots involved and producing purely subjective sensory symptoms, such as burning, gnawing and tingling, which may be increased by movement of the extremity.

Spurling's[10] patient complained of severe pain in the lower neck and tip of the shoulder and pain and inability to abduct the left arm. The onset of the disability was preceded by a "strain of the neck." The pain was exacerbated by sneezing, coughing and straining. On the first admission tenderness of the fifth and sixth cervical spinous processes and hypesthesia in approximately the fifth cervical dermatome over the tip of the shoulder were found. Nine years later there was atrophy of the left deltoid and infraspinatous muscles and inability to abduct the left arm, in addition to the sensory changes previously observed. The total protein in the cerebrospinal fluid was 80 mg. per 100 cc. A doubtful filling defect on the left between the sixth and seventh cervical vertebras was seen on lipiodol examination. Laminectomy revealed a mass compressing the sixth cervical nerve root against the overlying ligamentum flavum. It was not removed because "direct attack on the protrusion would have led to damage to the nerve and possibly the spinal cord." The decompression gave relief of symptoms.

Hanflig[11] described a case with a herniated nucleus pulposus at the sixth cervical interspace. The patient complained of pain, aggravated by coughing, sneezing and straining, in the left side of the neck, left costocoracoid area, left arm, left forearm and second and third fingers, with paresthesias of these two fingers — hyperesthesia to pinprick and hypesthesia to touch and vibration. The total protein in the cerebrospinal fluid was 83 mg. per 100 cc. Fluoroscopy after lipiodol injection disclosed an extramedullary lesion between the sixth and seventh cervical vertebras. Laminectomy and removal of the disk fragment gave complete relief of symptoms. Head traction had previously been used without effect.

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Semmes and Murphey[12] observed a group of 4 cases with apparent unilateral rupture of the sixth cervical disk, in 3 of which this diagnosis was proved at operation. They proposed a syndrome characterized by pain in the neck, shoulder, precordium and arm and by sensory changes in the index and middle fingers. The pain was made worse by sneezing, coughing and straining and by movements of the neck. The important findings on examination included tenderness over the exit of the seventh cervical nerve root from the spinal canal and over the scapula, hypesthesia in the index finger, slight reduction of sensibility of the middle finger, normal arm and leg reflexes and absent cervical lordosis on the x-ray films. The total protein was increased in 2 cases. No lipiodol examinations were performed. The site of the lesion was localized during the operation, which was carried out under local anesthesia. Gentle pressure on the ligamentum flavum reproduced the pain, and novocain infiltration of the corresponding nerve root abolished it. Two of these patients were completely relieved.

The present report is based on experiences with 8 cases, all of which were proved pathologically at operation. There were lesions at the fifth cervical interspace in 4 cases, at the sixth in 3, and at the seventh in 1, with encroachment on the sixth, seventh and eighth cervical nerve roots, respectively.

Case Reports

Case 1 (M. G. H. 334269). A. T. S., a 45-year-old unemployed weaver, was admitted to the Massachusetts General Hospital for the second time in April 23, 1934, because of pain and weakness of left shoulder and arm. Twenty-two months prior to admission, a crank he was turning to raise the body of a dump car slipped and struck his left arm just below the deltoid muscle. There was local pain for several days. Eleven months later pain and numbness began in the anterolateral left upper arm, antecubital region and forearm; it was made worse by movements of the arm, which became weaker and smaller.

Examination revealed atrophy of the left upper arm, particularly of the deltoid and biceps. There were muscle twitchings of the deltoid. The arm reflexes were apparently equal, the left knee jerk was more active than the right, and the left plantar response was equivocal. There was hyperesthesia to pinprick and temperature in the antecubital region and a small area above the spine of the scapula. A lumbar puncture showed a protein level of 43 mg. per 100 cc. The cisternal fluid contained 24 mg. The dynamics were equivocal. A lipiodol examination was unsuccessful because the lipiodol could not be moved from the cistern.

At operation a hard, fibrous mass of tissue 1.0 cm. in diameter and 0.2 cm. in thickness was found between the 5th and 6th cervical vertebras impinging on the cord. Because of brisk bleeding it was not removed. On later check-up examination the patient was found to have weakness of the biceps and deltoid but was able to do odd jobs.

Case 2. (M. G. H. 27277). O. A., a 49-year-old automobile-body worker, was admitted to the hospital on March 4, 1937, complaining of pain in the right shoulder and arm. He had been entirely well until 5½ months previously, when he fell, striking the back of his neck and right shoulder on a projection. He had pain in that region for 30 minutes and then resumed his work. One week later, he began to have pain in the posterior right side of the neck, right shoulder and upper arm and a sensation of numbness in the upper arm, made worse by coughing, sneezing, straining and motion and not relieved by medication, physiotherapy or strapping. A Thomas collar improved the pain, except on sneezing and coughing, for 8 weeks, when the symptoms progressed. Pain in the back of the neck, shoulder and arm became severe. Flexion, extension and lateral flexion of the neck caused numbness involving the whole arm and hand, particularly the thumb and index finger. The arm became weak and there were tremors of the muscles of the upper arm.

Examination revealed tenderness to the right of the 5th cervical vertebra and the spine of the scapula, the latter being accompanied by numbness in the arm. There was some weakness of the right arm and hypesthesia over the radial side of the forearm and the deltoid region. The reflexes of the right arm were diminished and the right ankle jerk was more active than the left. There were no pathologic reflexes. The cerebrospinal-fluid protein was 60 mg. per 100 cc. at the lumbar level and 17 mg. at the cisternal. Lipiodol examination revealed a partial block at the upper margin of the 6th cervical body. On laminectomy the 6th cervical root was found to be compressed by a ruptured disk fragment, which was removed. The patient was improved when discharged. On check-up examination and by correspondence later it was found that the patient continued to have some soreness of the right upper arm and forearm.

Case 3 (M. G. H. 181151). J. F. B., a 38-year-old bartender, was admitted to the hospital on March 30, 1939, for pain and paresthesias in the left shoulder and arm. Five years previously he was struck by an automobile, and he grasped the radiator cap to ride the car with his knees on the bumper. There was stiffness of the neck for 4 to 5 weeks, diagnosed as strain of the cords of the left neck and shoulder. Five months previously he noticed a sensation of "pins and needles" in the left arm when he was tipped back in a barber's chair, the sensation persisting until the headrest was raised. Since then this sensation had been felt more frequently, particularly in tilting the head to the left and lying on the left shoulder. Two months later the patient began to suffer from constant tearing pain in the anterolateral region of the left upper arm and scapula. The paresthesias became almost constant, involving the radial forearm, thumb and index finger. The discomfort was aggravated by tilting the head to either side, use of the left arm and lying on the left shoulder. Some relief was obtained by raising the left arm over the head.

On examination all movements of the head against resistance and to the left without resistance produced pain over the scapula and anterolateral upper arm and paresthesias in the left radial forearm, thumb and index finger. There was some hyperalgesia over the left shoulder blade and antecubital space and hypesthesia of the left thumb. The left radial and biceps reflexes were less active than those on the right. Other reflexes were normal, and there were no pathologic reflexes. X-ray examination showed absence of cervical lordosis. Lipiodol examination was suggestive of delay in the transport of the lipiodol between the 5th and 6th cervical vertebras on the left side. The total protein of the cerebrospinal fluid was 47 mg. per 100 cc. at the lumbar level and 25 mg. at the cisternal.

Laminectomy revealed a ruptured disk fragment compressing the 6th cervical nerve root, which was removed. The patient was symptom free after recovery from the operation, and remained so at a check-up examination two months later, at which time he was ready to go back to work.

Case 4 (M. G. H. 397940). L. A. T., a 53-year-old farmer, entered the hospital on March 25, 1943, with complaints of pain in the neck, left shoulder and arm. Twenty years previously he fell 12 feet from a barn roof, hitting the ground with his feet down and suffering a fracture of the right knee. Six weeks before admission he slipped on the ice, wrenching his left shoulder. The pain in the left arm began 6 years previously, at first occurring only during the night. It involved the antecubital region and was associated with numbness. After the second accident both the pain and the numbness became more continuous and widespread, including the lower midcervical region and left shoulder blade and radiating over the collarbone into the deltoid region and the radial forearm. The pain, which was described as "like electricity" and "like a toothache," was made worse

by turning the head to the right and by flexing it. Traction also made it worse.

On examination the head was seen to be tilted to the right. The cervical spine was held rigid and was tender to pressure over its lower part. There was marked atrophy of the left deltoid muscle. Motions of the left arm and hand were weak at all joints. There was hypesthesia of the lateral aspect of the upper arm and the radial aspect of the forearm. The left biceps, radial and abdominal reflexes were less active than those on the right, both triceps reflexes were absent, the left knee and ankle jerks were more active than those on the right, and there was a Babinski sign on the left. X-ray examination of the cervical spine revealed absence of cervical lordosis and slight tilting of the head to the right. The left side of the diaphragm was elevated. Lipiodol examination showed a suggestive defect at the level of the 5th cervical interspace. The total protein of the lumbar cerebrospinal fluid was 75 mg. per 100 cc.

At operation a disk fragment compressing the left 6th cervical nerve root was found and removed. Recovery was uneventful and relief was complete. The patient returned to his old job and subsequently reported, "My health is the best it has been for many years."

Case 5 (M. G. H. 296875). J. H. O., a 43-year-old engineer, was brought to the hospital on April 8, 1941, because of weakness of both legs and arms. Twenty-three years previously he had a fall while on cavalry drill in France. Three years later he began to have "stiff necks" and pain in the left shoulder and arm, intermittently. Later on, these attacks occurred more frequently. Three weeks prior to admission he noticed a steady, sharp pain over the left shoulder blade, dorsolateral upper arm and dorsal forearm and paresthesias in the index and middle fingers, which were aggravated by moving the spine. Because of this pain he had been unable to lie in bed for the past week. A physician recommended extraction of three teeth. When the third molar was pulled, the patient's whole body stiffened. A severe shooting pain in both hands and both feet was noted and the old shoulder and arm pain disappeared. When he tried to get out of his car at home he was unable to move his hands and feet, which felt numb. During the next few hours the strength in the arms and right leg partially returned, but he was unable to pass his urine and was incontinent of feces.

Examination revealed a marked weakness of the left leg, weakness of the right leg and weakness of the grip of both hands, more so on the left side. There was anesthesia to pinprick and temperature over the right side of the body, with its upper level at the clavicle and the inner side of the right arm. There was hypesthesia to pinprick and temperature over the left chest, the left inner arm and the dorsolateral aspect of the upper arm and forearm. The arm and leg reflexes were brisk and more active on the left side than on the right. There were unsustained knee and ankle clonuses, and the plantar reflexes were equivocal and possibly extensor on the left side. The bladder was paralyzed. Compression of the jugular veins produced increased numbness. A lumbar puncture showed a complete block and a total protein of 67 mg. per 100 cc. X-ray examination of the cervical spine revealed narrowing of the 5th and 6th cervical interspaces and extensive spur formation in the anterior margins of the 5th, 6th and 7th cervical vertebras.

At operation a disk fragment was found compressing the 7th cervical root on the left side and was removed. Following the operation the patient had a complete paralysis of both legs, which gradually subsided with return of bladder and bowel function. He is able to walk and use his arms and does odd jobs, but there is still a marked pyramidal deficit.

Case 6 (M. G. H. 392078). V. T., a 32-year-old floorman was admitted to the hospital on February 12, 1943, for pain in the right scapular region and right arm. Sixteen years previously he had a fall, landing on his neck. There was weakness in both arms and numbness and tenderness over the anterior chest below the clavicles for 2 or 3 months. Nine years previously he suffered a concussion while playing football, with loss of consciousness for 1 or 2 hours. Two years later he noticed pain in the right scapular region, which was not affected by motions of the neck and was relieved by the extraction of teeth.

Six months prior to admission, the patient noticed pain over the upper part of the right scapula, particularly on bending the neck forward and backward. Two months later the back pain was accompanied by shooting pain in the right side of the chest, the anterolateral aspect of the upper arm, the antecubital region and the radial forearm. This pain was aggravated by sneezing and coughing. It could be relieved by extending the arm over the head. There was also a constant ache in the upper arm and forearm and tingling of the fingertips. Traction and medication were of no effect. The right arm became gradually weaker, pushing motions being chiefly affected. There were also twitchings of the biceps muscle and trembling of the hand.

Examination revealed atrophy of the right triceps and deltoid muscles, weakness on abduction at the shoulder and on extension of the forearm and fasciculations of the deltoid muscle. There were no distinct sensory disturbances. The right triceps reflex was less active than the left. Other reflexes were normal. X-ray examination of the cervical spine showed narrowing of the 6th cervical interspace. The total protein of the lumbar cerebrospinal fluid was 67 mg. per 100 cc. Lipiodol examination showed delay of transport opposite the 6th cervical interspace on the right.

At operation a disk fragment was found compressing the right 7th cervical root and was removed. The pain was instantly relieved and convalescence was uneventful. The strength and size of the affected muscles gradually became normal. The patient returned to work 3 months after the operation. At a recent check-up examination he stated, "I am lifting 20 tons of clothes each day."

Case 7 (M. G. H. 407258). E. F., a 43-year-old mill hand, was admitted to the hospital on June 17, 1943, because of pain in the left shoulder and left arm. Six months previously while wrestling he fell against a parked car, striking his eye; three stitches were taken in the eyelid. Five weeks prior to admission he began to have severe stabbing pain involving the left shoulder blade, the dorsolateral aspect of the left upper arm and the dorsolateral aspect of the forearm on bending the head backward or turning it to the left side. The pain was associated with a tingling sensation in the dorsolateral forearm and index finger. The pain and numbness gradually became more severe and almost constant. Twitchings of the biceps muscle were also noted.

Examination showed atrophy of the left upper arm and muscle-bundle twitchings of the biceps muscle. There was marked weakness of the triceps muscles, mild weakness of the biceps muscles and some weakness of the other muscles of the forearm and hand. Hypesthesia was found over the dorsolateral aspect of the upper arm and forearm. The triceps reflex was diminished; other deep and superficial reflexes were normal. X-ray examination of the cervical spine revealed absent cervical lordosis and narrowing of the 6th cervical interspace. Lipiodol examination suggested an obstruction to the flow at a point opposite the left side of the 6th cervical interspace. The total protein of the cerebrospinal fluid was 48 mg. per 100 cc. at the lumbar level and 28 mg. at the cisternal. At operation a disk fragment was found compressing the left 7th cervical root and was removed. The postoperative course was uneventful. The patient was entirely relieved, returning to his job 4 weeks after the operation and continuing regularly since then.

Case 8 (M. G. H. 221689). C. H. M., a 68-year-old physician, entered the hospital on November 10, 1939, with complaints of pain involving the left scapula, the ulnar side of the left arm and the little finger. Three weeks previously, while pitching horseshoes, he twisted his back and felt deep underneath the left scapula a sudden, sharp pain that radiated across the axilla down the inner upper arm, elbow and forearm into the little finger. The pain was intermittent at first, but became more constant and dull. There also was numbness in the little finger. The pain was relieved by abduction and external rotation of the upper arm with internal rotation of the forearm — by grasping the head of the bed or resting the hand under the head. The pain was increased by extension of the head.

Positive findings included tenderness of the 7th cervical spinous process, with radiation of pain down the inner arm to the little finger. The pain was reproduced by hyperextension of the head and deep pressure in the left supraclavicular

area. Extension of the forearm, adduction of the thumb, flexion of the little finger and adduction and abduction of all the fingers were slightly weak. The little finger and inner arm were a little less sensitive to pain, temperature, touch and vibration than normal. The reflexes were equal and normal with the exception of the left triceps reflex, which was extremely sluggish. No pathologic reflexes were found. X-ray examination showed mild hypertrophic changes about the margins of the lower cervical and dorsal vertebras and diffuse osteoporosis. Lipiodol examination was inadequate owing to the patient's condition. The total protein in the lumbar spinal fluid was 103 mg. per 100 cc. and that in the cisternal 49 mg. Head traction was tried but was not tolerated.

At operation the left 8th cervical root was found to be compressed by a disk fragment, which was removed. Convalescence was uneventful and the pain disappeared. The patient was able to resume practice three months after the operation.

The Root-Compression Syndrome

In spite of the difference in level these cases had certain features in common. These will be analyzed first, after which the syndromes characteristic of each level will be discussed.

All the 8 patients at some time prior to the onset of their recent illness received an injury. The different types of injury, the age and sex of the patients at the time of admission, the onset and the type of symptoms are summarized in Table 1.

Table 1. *Nature of Injury and General Symptomatology.*

Case No.	Age	Sex	Injury		Immediate Symptoms	Late Symptoms	
			time	nature		duration	nature
	yr.						
1	44	M	22 mo. ago	Crank struck left arm	Pain in deltoid region for several days	11 mo.	Pain, paresthesias and weakness in left arm and shoulder
2	49	M	5½ mo. ago	Struck back of neck and right shoulder on projection	Pain in right deltoid region for ½ hr.	5 mo.	Pain, paresthesias and weakness in right arm and shoulder; twitchings
3	38	M	5 yr. ago	Struck by car	Stiffness in neck and left shoulder for 4 to 5 wk.	5 mo.	Pain and paresthesias in left arm and shoulder
4	53	M	20 yr. ago	Fell 12 feet, landing with right foot on a boulder	Fracture of right knee — exacerbation of shoulder and arm pain	5 to 6 yr.	Pain and paresthesias in left shoulder and arm
			6 wk. ago	Slipped on ice, wrenched left shoulder			
5	43	M	23 yr. ago	Fell off horse	Apparently no ill effects	22 yr.	Intermittently stiff neck, pain and paresthesias in left shoulder and arm; recently sudden paraplegia
			3 wk. ago	Forceful manipulation of neck	Paraplegia		
6	32	M	17 yr. ago	Fell on neck	Arms "paralyzed" for 3 wk.; numbness and tenderness over chest	6 mo.	Pain, paresthesias and weakness in right arm and shoulder; twitchings
7	43	M	6 mo. ago	Fell against car while wrestling	Laceration above eye; headaches	6 wk.	Pain and paresthesias in left shoulder and arm; twitchings
8	68	M	3 wk. ago	Twisted back pitching horseshoes	See case record	3 wk.	Pain, paresthesias and weakness in left shoulder and arm

The ages varied from thirty-two to sixty-eight years, with an average age of forty-six years. All the patients were men. In 6 cases the left side was involved.

The symptoms that brought the patients to the hospital were pain associated with paresthesias in the region of the scapula, arm and hand. The pain was usually described as stabbing, shooting, sharp or acute. Only 3 patients complained also of pain in the lower part of the neck. In 3 others there was no history of discomfort referable to the neck. Two patients noticed pain and paresthesias in the scapular region and arm for the first time on certain movements of the neck. All patients except 1, however, stated that movements such as turning and tilting the head and forward and backward bending of the neck made their discomfort worse. Other exacerbating factors were motions of the involved arm except for combined abduction and external rotation of the upper arm and internal rotation of the forearm, which were used by 3 patients to relieve the pain. Sneezing and coughing as aggravating factors were recorded in 3 cases.

Four patients complained of weakness of the arm, and 3 of them observed twitchings of some of the arm muscles.

The duration of the symptoms varied from three weeks to twenty-two years. In 4 patients it was from five to seven months.

In only 1 case did the onset of the characteristic disturbances occur at the time of the trauma. In the other patients the symptoms immediately following the injury were different from those experienced weeks, months or many years later. It should be mentioned, however, that the patient in Case 3 had a stiff neck for four or five weeks following the injury. It was diagnosed as strain of the cords of the left neck and shoulders. In Case 6 there was motor paralysis of both arms and paresthesias for three weeks after the patient's fall. In Case 4 the patient, who suffered two accidents, noticed an exacerbation of the symptoms after the second one.

During the course of the recent illness in any given case the type of symptoms remained about the same, but the intensity of the sensory manifestations increased and weakness, if present, became more pronounced. Only in 1 case (Case 5) did the type of symptoms change entirely, the patient becoming paralyzed during a dental operation. He was included in this series because for twenty-two years he had suffered from intermittent spells of stiffness of the neck and shooting pains in

the left shoulder and upper arm much like those experienced by the other patients.

The motor and sensory findings are summarized in Table 2. On the involved side weakness of certain muscles and diminution of arm reflexes were observed in 7 cases and atrophy and fasciculations in 4. Marked involvement of the pyramidal tracts was present in Case 5. In 3 other patients mild unilateral pyramidal signs were found without weakness. They were on the same side as the symptoms and signs produced by the root compression in the cervical region.

Impairment of sensation in some parts of the upper extremity was recorded in 7 cases. Other parts of the body were normal except in Case 5, in which there was a Brown–Séquard syndrome, and Case 2, in which the disturbance was indefinite.

Tenderness of the lower cervical spine was demonstrated in 3 cases, of the scapula in 2, and of the arm muscles in 2 cases.

The examination of the lumbar cerebrospinal fluid revealed an elevated protein in 5 patients and high borderline values in the others. In only 1 case was the cisternal fluid abnormal. The dynamics were not affected except in Case 5, which had a complete block.

X-ray examination of the cervical spine showed narrowing of an interspace in 3 cases, hypertrophic changes of the lower cervical spine in 4 and absent cervical lordosis in 4. Narrowing of an interspace was always associated with hypertrophic changes. In 2 cases there was a combination of narrowing, hypertrophic changes and absent lordosis.

The different distribution of the sensory manifestations resulting from root compression at the fifth, sixth and seventh interspaces is shown in Table 3. There was involvement of the scapula, the anterolateral aspect of the upper arm, the antecubital space, the radial side of the forearm and the thumb and index finger in herniations at the fifth interspace (sixth cervical root). The scapula, the dorsolateral aspect of the upper arm, the dorsal aspect of the forearm and the index and middle fingers were affected by compression of the seventh cervical root at the sixth interspace. The lesion at the seventh interspace (eighth cervical root) produced sensory abnormalities of the scapula, the inner side of the upper arm and forearm and the little finger.

There was obvious motor dysfunction of the biceps and deltoid muscles in 2 cases with compression of the sixth cervical root, and of the deltoid, biceps and triceps muscles in 2 cases with involvement of the seventh nerve root. Implication of the eighth nerve root seemed to be associated with weakness of the triceps, adductor of the thumb,

TABLE 2. *Motor and Sensory Disturbances.*

Case No.	Side of Lesion	Motor Disturbances: Arm (on side of lesion)				Legs		Sensory Disturbances: Arm (on side of lesion)	Other parts of body
		Atrophy	Weakness	Fibrillations	Reflexes	Weakness	Reflexes		
1	Left	Yes	Yes	Yes	Normal(?)	No	Left knee jerk more active; left plantar indefinite	Yes	No
2	Right	No	Yes	Yes	Diminished	No	Right ankle jerk more active	Yes	Possibly right side of neck and chest
3	Left	No	No	No	Diminished	No	Normal	Yes	No
4	Left	Yes	Yes	No	Diminished	No	More active on left; left Babinski	Yes	No
5	Left	No	Yes	No	More active	Yes	More active on left; plantar indefinite	Yes	Yes
6	Right	Yes	Yes	Yes	Diminished	No	Normal	No	No
7	Left	Yes	Yes	Yes	Diminished	No	Normal	Yes	No
8	Left	No	Yes	No	Diminished	No	Normal	Yes	No

TABLE 3. *Regional Sensory Disturbances.*

Case 1 (fifth interspace)	Case 2 (fifth interspace)	Case 3 (fifth interspace)	Case 4 (fifth interspace)	Case 5 (sixth interspace)	Case 6 (sixth interspace)	Case 7 (sixth interspace)	Case 8 (seventh interspace)
Scapula (Pr, Hr)	Scapula (P)	Scapula (P, Hr)	Scapula (P)	Scapula (P)	Scapula (P)	Scapula (P)	Scapula (P)
Anterolateral upper arm (P, Pr)	Anterolateral upper arm (P, Pr, H)	Anterolateral upper arm (P)	Anterolateral upper arm (P, Pr, H)	Dorsolateral upper arm (P)	Dorsolateral upper arm (P)	Dorsolateral upper arm (P, H)	Inner upper arm (P)
Antecubital region (P, Hr)	Radial forearm (H)	Antecubital region (Hr)	Antecubital region (P, Pr)	Dorsal forearm (P)	Chest (P)	Dorsolateral forearm (P, Pr, H)	Inner forearm (P)
Forearm (P)	Thumb and index finger (Pr)	Radial forearm (Pr)	Radial forearm (P, Pr, H	Index and middle fingers (Pr)	Dorsolateral forearm (P)	Index finger (Pr)	Little finger (P, Pr, H)
		Thumb (Pr, H)			Fingertips (Pr)		
		Index finger (Pr)					

Abbreviations: P—Pain; Pr—Paresthesias; H—Hypesthesia; Hr—Hyperesthesia.

flexor of the little finger and interossei muscles.

The narrowing of the sixth interspace shown on the x-ray plates was at the sixth interspace in all 3 cases with the lesion at this level.

Lipiodol examination was done in 7 cases, with suggestive results in 4 of them.

Comment

The data just presented indicate that pain and disability of the shoulder and arm were the prominent symptoms in this group of patients.

The character of the pain and its association with paresthesias suggested that it was due to involvement of the nervous system. It was exacerbated by flexion, hyperextension and tilting of the neck and certain movements of the arm, and also by sneezing and coughing. It did not follow the course of any particular peripheral nerve. These features and the demonstration of the underlying pathology make it certain that the pain resulted from disease involving the sensory roots. One also may infer that the areas in which this pain and the other sensory abnormalities occurred represented the dermatomes supplied by the affected posterior roots.

With herniations at the fifth interspace, the scapula and the anterolateral aspect of the upper arm were involved in all 4 cases and the antecubital region and radial forearm in 3 cases. The site on the forearm in 1 case was not recorded. The thumb and index finger were affected in 2 cases. Figure 1 shows that this pattern follows fairly closely the arrangement of the sixth cervical dermatome as outlined by Foerster,[13] with the exception of the radial forearm. On the chart by Pauchet and Dupret[14] the sixth cervical dermatome is represented on the radial forearm.

In the second group with herniations at the sixth interspace, the scapula, dorsolateral upper arm and dorsal forearm were implicated in all cases, the index and middle fingers, and the index finger alone in 1 case each, and the fingertips in the third case. The scapular pain, which was definite, could not be explained by using Foerster's outline. In Pauchet and Dupret's outline the seventh cervical dermatome is represented in this area. In both figures the seventh cervical dermatome does not include the dorsolateral aspect of the upper arm.

The only patient in this group who had a herniation at the seventh interspace presented sensory manifestations in accordance with the outline of Pauchet and Dupret, including the shoulder blade, the inner, upper and lower arm and the little finger.

The distribution of the sensory phenomena in the upper arm and forearm and shoulder appeared to be consistent and characteristic for each root. The pattern of the sensory manifestations of the fingers was not uniform. In 2 cases with involvement of the sixth cervical root the fingers remained free. The index finger, which Semmes and Murphey[12] believe is almost entirely innervated by the seventh cervical root, and the thumb were affected in the other 2 cases. Compression of the seventh cervical root produced manifestations in the index finger, both in the index and middle finger, and on the fingertips. These differences were probably due to variations of the dermatome distribution, which are known to occur particularly in the fingers.[13, 14]

The question may also be raised whether involvement of the scapula, observed in all the patients

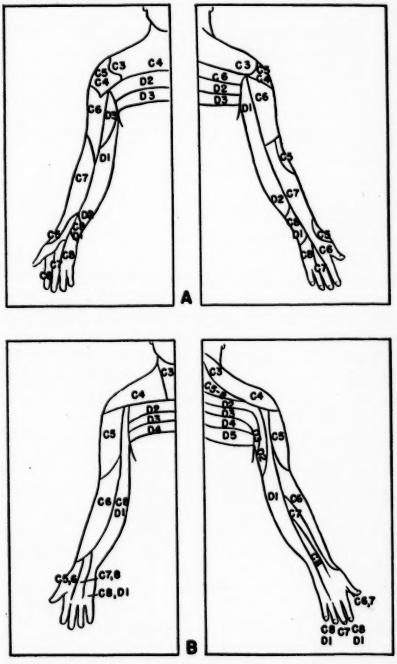

Figure 1. *Distribution of Cervical Dermatomes. The upper drawings* (A) *are according to Foerster,*[13] *and the lower* (B) *according to Pauchet and Dupret.*[14]

regardless of the level, is due to an overlap phenomenon or a true representation of the affected roots in this area. Study of a larger number of cervical-disk cases will be necessary for a better understanding of all these problems, and perhaps of the extent of cervical dermatomes in general. The different outlines found in the textbooks are extremely confusing.

Semmes and Murphey did not describe the distribution of the arm pain in their patients with herniation of the sixth interspace. Their findings with reference to the index and middle fingers and

shoulder are in agreement with ours. The question of heart disease as the underlying pathology did not come up in these cases. Only 1 patient experienced pain over the chest, but he had a right-sided lesion.

The absence of neck pain in 5 of 8 patients is worth emphasizing.

As to the motor dysfunction, diminution of reflexes of the involved arm were usually present without significant difference of the biceps, triceps, and radial reflexes at different levels of the herniation.

Weakness, atrophy and twitchings of the biceps and deltoid muscles were recorded in lesions at the fifth interspace, of the deltoid, biceps and triceps muscles at the sixth, and of the triceps, adductor pollicis, flexor digiti quinti and interossei muscles at the seventh. The records, however, were not too clear with reference to the analysis of the motor disability, perhaps because pain interfered with a systematic examination. A more detailed examination and the use of chronaxie determinations and electromyograms in the future may be of some value for a better definition of the motor changes. The number of the muscles affected by involvement of the respective anterior roots should be greater than have been observed if the present knowledge of the motor segmental innervation is correct.

With the exception of Case 5, which can be omitted from the discussion, symptoms of the long tracts of the spinal cord were absent. The dynamics of the cerebrospinal fluid were normal, and although mild or equivocal pyramidal signs were recorded in 4 cases, the basic clinical picture in all 7 cases was not due to cord compression.

X-ray changes of diagnostic value comprised absent cervical lordosis and narrowing of the sixth cervical interspace. The latter was found in all 3 cases with herniation at this level. Semmes and Murphey found loss of the cervical curve in 2 cases but no narrowing of the disk. The cerebrospinal fluid examination was useful when the total protein was elevated. In 2 of the cases with a doubtful value, x-ray changes and other evidence led to a lipiodol examination, which suggested the presence of the lesion.

The lipiodol findings were negative in only 1 case; in 2 cases it could not be moved from the site of the injection, and in 4 cases there was a delay of the passage of the oil at the level of the protruded disk. In the more recent cases the oil was removed after the examination at the lumbar level, as suggested by Kubik and Hampton.[4]

Differential Diagnosis

When a patient presents himself with ordinary complaints of pain in the shoulder and arm, the discovery of the true seat of the disease may be beset with difficulties. Arthritis of the spine and shoulder, bursitis, brachial neuralgia and neuritis, cervical rib, elongated transverse processes of the seventh cervical vertebra and more recently scalenus anticus syndrome are popular diagnoses. Semmes and Murphey[12] emphasized the similarity of their syndromes and coronary disease. One might as well also include gall-bladder disease if the herniation is on the right side, pleurisy and tumors of the apex of the lung. Some of these syndromes are vaguely defined clinically as well as pathologically and their separation from each other is not always possible. The addition of a new entity to this long list seems to complicate things even more, but actually it may simplify the problem. Undoubtedly a fair number of cases formerly treated under one of the customary diagnoses will be interpreted and handled more rationally if the picture of cervical-root compression by a disk fragment becomes better known.

It is beyond the scope of this paper to discuss seemingly similar symptoms and signs of the aforementioned entities and the syndrome of a ruptured disk. Usually a good history with careful evaluation of the complaints shows the specific nature of the symptoms. As pointed out before, root pain has certain characteristics. If it is not recognized as such by its quality and distribution, its onset and course and the factors that aggravate or relieve it may be suggestive. Acromial bursitis, for instance, interferes with the abduction and outward rotation of the upper arm, which is very painful. Several of these patients volunteered the information that this particular movement relieved their pain. The mechanical irritation by a cervical rib or tight scalenus anticus muscle is lessened by tilting the head to the affected side; the reverse was true in these cases.

Regardless of whether the complaints of the patient can be properly evaluated, a systematic neurologic examination, including lumbar puncture and possibly lipiodol studies, is indicated, if other measures fail to disclose some definite underlying lesion. Occasionally a lumbar puncture alone or the combination of an absent cervical lordosis and narrowing of an interspace decides the issue, but it is not one symptom or sign that characterizes a clinical entity. A satisfactory diagnosis is based on collateral evidence.

Table 4 shows the more important findings in 7 cases.* Every one of these patients showed a combination of signs that is not compatible with extraspinal disease. The syndrome was that of intraspinal disease, unlike that of a tumor or syringomyelia, not to mention other less relevant possibilities.

Treatment

All patients had various forms of treatment prior to their hospital admission, without permanent relief. Such measures comprised baking and massage,

*Case 5 was omitted because of obvious cord compression on admission.

lamp treatments, strapping and head traction. One patient was injected locally with novocain.

The laminectomy and removal of the disk fragment produced good results in 6 cases. In 1 case the improvement was not too impressive. In one of the early cases in which the disk fragment could not be removed for technical reasons, the pain was relieved but the motor disability persisted. In Case 5, with recent cord compression, gradual improvement of the motor and sensory functions of the long tracts and roots took place. The other patients were relieved of their pain dramatically. The recovery of muscle function, if impaired, was gratifying.

In the recent cases the operation consisted of subtotal hemilaminectomy. Small pieces of bone were removed from the adjacent lamina on one side. A lateral opening in the dura was made and only the nerve roots were exposed. After gentle retraction of the roots the disk was removed transdurally.

TABLE 4. *Summary of Data.*

Case 1	Case 2	Case 3	Case 4	Case 6	Case 7	Case 8
Left root pain increased by certain movements of left arm; paresthesias	Right root pain increased by certain movements of neck and right arm, sneezing and coughing, paresthesias	Left root pain increased by certain movements of neck and left arm; paresthesias	Left root pain increased by certain movements of neck and left arm; paresthesias	Right root pain increased by certain movements of neck and right arm, sneezing and coughing; paresthesias	Left root pain increased by certain movements of neck and possibly left arm, sneezing and coughing; paresthesias	Left root pain increased by certain movements of neck and left arm; paresthesias
Left segmental sensory disturbances	Right segmental sensory disturbances	Left segmental sensory disturbances	Left segmental sensory disturbances	Right arm atrophy, weakness, fibrillations; right arm reflexes diminished	Left segmental sensory disturbances	Left segmental sensory disturbances
Left arm: atrophy, weakness, fibrillations	Right arm: weakness; fibrillations; right arm reflexes diminished	Left diminished arm reflexes	Left arm: atrophy weakness; left arm reflexes diminished	Narrowing of 6th cervical interspace; absent cervical lordosis	Left arm: atrophy, weakness, fibrillations; left arm reflexes diminished	Left arm: weakness; left arm reflexes diminished
Left knee jerk increased; indefinite plantar.	Right ankle jerk increased	Absent cervical lordosis	Left leg reflexes increased; left Babinski		Narrowing of 6th cervical interspace; absent cervical lordosis	
			Absent cervical lordosis			
Total protein: 43 mg. per 100 cc.	Total protein: 60 mg. per 100 cc.; partial lipiodol block	Total protein: 47 mg. per 100 cc.; partial lipiodol block	Total protein: 75 mg. per 100 cc.; partial lipiodol block	Total protein: 67 mg. per 100 cc.; partial lipiodol block	Total protein: 48 mg. per 100 cc.; partial lipiodol block	Total protein: 123 mg. per 100 cc.

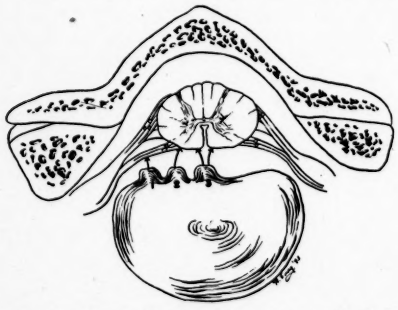

FIGURE 2. *Diagram Showing Various Types of Herniation of the Cervical Disk.*

The three types are as follows: 1 — *herniation producing cord compression;* 2 — *herniation producing unilateral compression of the ventral root (Stookey's Group II); and* 3 — *herniation producing bilateral compression of the ventral roots (Stookey's Group I).*

Figure 2 shows the approximate location of the disk fragment as compared with the fragments in Stookey's group producing cord compression.

All the operations in this series were performed under general anesthesia. Consequently we have no experience with the determination of the level of the lesion by pressure on the yellow ligament and subsequent novocain injection, as suggested by Semmes and Murphey. Their procedure may be the method of choice in cases suitable for local anesthesia.

SUMMARY AND CONCLUSIONS

Eight cases of herniation of the nucleus pulposus in the lower cervical spine are reported. There were lesions at the fifth cervical interspace in 4 cases, at the sixth in 3 and at the seventh in 1, with involvement of the sixth, seventh and eighth cervical roots, respectively.

The clinical data were brought together in a syndrome that comprised root pain and local sensory and motor disturbances, as well as positive x-ray, cerebrospinal-fluid and lipiodol findings.

The distribution of the sensory abnormalities was compared with standard dermatome charts. In these cases the sixth cervical dermatome seemed to involve the scapula, the anterolateral aspect of the upper arm, the antecubital space, the radial forearm and its thumb and index finger. The seventh cervical dermatome seemed to involve the scapula,

the posterolateral aspect of the upper arm, and the dorsal surface of the forearm and the index and middle fingers. The eighth cervical dermatome seemed to involve the scapula, the inner and upper arm, the forearm and the little finger.

The importance of a systematic neurologic examination in cases with pain or disability of shoulder and arm is emphasized, to separate the apparently specific syndrome of cervical herniations of the nucleus pulposus from other extraspinal and intraspinal entities.

The results of the removal of the disk fragments by laminectomy — more recently by subtotal hemilaminectomy — were good.

The clinical data of 3 cases included in this paper were obtained through the courtesy of Drs. J. S. Hodgson, T. J. Putnam and J. C. White.

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SEROLOGIC TYPES OF HEMOLYTIC STREPTOCOCCI ISOLATED FROM SCARLET FEVER IN MASSACHUSETTS, 1942–1943*

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DURING 1942 and 1943, hemolytic streptococci isolated from the throat swabs of patients with scarlet fever admitted to various Massachusetts hospitals were classified as to serologic type. The laboratory studies were carried out at the Department of Preventive Medicine, Harvard Medical School,§ and arrangements for the provision of throat cultures were made possible through the cooperation of the Division of Communicable Diseases of the Massachusetts Department of Public Health.¶

In this period a total of 631 throat swabs were examined, of which 427 (67.7 per cent) were positive for Group A hemolytic streptococci. The low percentage of positive cultures from scarlet-fever cases can be explained in part by the loss of viability of organisms sent through the mail. These strains were classified as to serologic type by the method of Griffith.[1] Slide agglutination was facilitated by the digestion of granular or self-agglutinating cultures by the tryptic digest method described by Allison.[2]

The serologic types of hemolytic streptococci isolated from scarlet-fever cases in different localities are presented in Table 1. The similarity of the predominant types of streptococci causing this disease in these various localities is noteworthy. In Table 2 the most frequent scarlet-fever types in two earlier Boston studies are compared with those encountered in the Massachusetts communities in 1942 and 1943, which are represented by community in Table 1. It is not possible to draw conclusions from these data concerning the limits of constancy of the streptococcus-type pattern in scarlet fever, but the emergence of certain predominant types and the tendency of others to decline or disappear can be seen.

The available data suggest that during the period of seasonal prevalence of streptococcal infection certain types maintain themselves as the cause of scarlet fever in a large proportion of cases. From these studies it is obvious that in Massachusetts the type pattern in scarlet fever varies from year to year. Further observations are necessary to determine the number of years that single types continue to occur predominantly in scarlet fever. There is a suggestion that Type 2 has maintained

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§Within the limits of laboratory facilities, it is possible for this laboratory to type hemolytic streptococci from scarlet fever and other infections occurring in the New England area. Swabs or cultures submitted should be accompanied by the patient's name and address, age, sex, date of onset of disease, date of culture, source of swab or culture and diagnosis and treatment (if any), together with the sender's name and address so that the results may be reported.

¶We are indebted to Dr. R. F. Feemster, director of the Division of Communicable Diseases, Massachusetts Department of Public Health, for making arrangements to carry on this study.

itself as a major cause of the disease during the months of high seasonal prevalence in both 1942 and 1943.

Evidence has accumulated in the literature that all the thirty or more well-established types have been found in scarlet fever. This is borne out by laboratory studies indicating that the common erythrogenic toxin, the so-called "N.Y.-5," is broadly valent over various serologic types in Group A and certain Group C strains of hemolytic streptococci.[5] The quality of toxigenicity is apparently a characteristic easily acquired or lost. Although the circumstances that favor the production of erythrogenic toxin by a given strain are not yet known, epidemiologic observations suggest that types vary in their production of toxin from time to time and from place to place. The appearance of predominant type patterns suggests that locally and temporally certain types are the most successful rash producers. The streptococcus types predominant in scarlet fever can be compared in epidemiologic behavior with the pneumococcus types most frequently associated with pneumonia.

A type study of scarlet-fever streptococcus strains in regions such as Massachusetts reveals that in addition to the predominant types, a variety of other strains are at times found in the admission cultures of patients. This serves to emphasize the essential unity of scarlet fever with other streptococcal infections. The appearance of a rash in a person with hemolytic streptococcus infection depends on the toxigenicity of the organism, a property that is present in varying degree in many types, and susceptibility of the host to this toxin, as indicated by the positive Dick test. As Gordon[6,7] has pointed out, a Dick-negative subject may contract an infection without rash from a case of scarlet fever and in turn transmit the infection to contacts in whom illness manifests itself in a rash only if they have a low immunity to the Dick toxin.

This variety of clinical manifestation is best observed in milk-borne or food-borne outbreaks of streptococcal infections caused by one strain or type infecting from a common source. The work of Stebbins, Ingraham and Reed[8] and of Dublin et al.[9] on milk-borne sore throat and scarlet fever reveals the importance of the antitoxic immunity of the host in determining the presence or absence of a rash in the resulting infection. Secondary cases in the same household may also show these characteristics. Table 3 shows the types of hemolytic streptococci isolated from multiple cases in the same family in this study. Infections without rash did not appear with scarlet-fever infections in this series. The cultures were submitted from contagious-disease hospitals, which are apt to admit patients with streptococcal infection only if a rash is present, in accordance with the usual public-health administrative

TABLE 1. *Predominant Types of Hemolytic Streptococci in Scarlet Fever in Massachusetts Cities.*

COMMUNITY	YEAR	NO. OF POSITIVE CULTURES	PREDOMINANT TYPES FIRST	SECOND	THIRD	PERCENTAGE OF PREDOMINANT TYPES
Boston	1942	19	2	19*	8	90
Worcester	1942	34	2	19*	8	80
Springfield	1942	6	19*	25	8	100
Fall River	1942	6	2	—	—	100
Norfolk	1942	5	2	—	—	100
Boston	1943	7	2	19*	—	100
Worcester	1943	351	2	1	8	71

*Weak cross reaction with Types 4, 24, 26 and 29.

TABLE 2. *Percentage Distribution of Predominant Types of Hemolytic Streptococci Isolated from Scarlet Fever in Massachusetts.*

STUDY	YEAR	NO. OF CASES TYPED	PREDOMINANT TYPES FIRST		SECOND		THIRD		PERCENTAGE OF PREDOMINANT TYPES
Boston[3]	1938–1939	340	15	(45%)	13	(4%)	11	(3%)	51.5
Boston[4]	1939–1940	35	2	(55%)	6	(11%)	—	—	66.4
Massachusetts	1942	69	2	(57%)	19*	(22%)	8	(6%)	85.6
Massachusetts	1943	358	2	(26%)	1	(26%)	8	(18%)	69.8

*Weak cross reaction with Types 4, 24, 26 and 29.

TABLE 3. *Serologic Types of Hemolytic Streptococci from Multiple Cases of Scarlet Fever and Other Infections in Thirty-six Families.*

SEROLOGIC TYPE IN MULTIPLE CASES	NO. OF PRIMARY AND CO-PRIMARY CASES	NO. OF SECONDARY CASES FROM HOUSEHOLD EXPOSURE
2	14*	19†
1	11	10
8	7	11
6	6	3
19	3‡	1
5	2	1
15	1	1

*Includes cases in one family diagnosed as septic sore throat.
†A case of abscessed finger secondary to a case of scarlet fever.
‡Includes 2 primary cases of streptococcal meningitis.

procedures. Undoubtedly a periphery of persons with nonscarlatinal infection was associated with these hospitalized family cases but were themselves not admitted to the hospital. The consistency of type in the infecting organisms from secondary cases in the same household, as shown in Table 3, seems to confirm that these secondary cases are the result of true household exposure.

The study of the distribution of streptococcus types in scarlet fever raises the question of the relation of the type pattern to the epidemiologic and clinical features of the disease. Relatively few data are available from North America on streptococcus typing. Table 4 gives the available information on scarlet-fever types from the literature and from unpublished work in the United States and Canada. These data may be compared with those from Great Britain, where extensive study carried on since 1926 shows that Types 1, 2, 3 and 4 cause at least half the cases of scarlet fever but vary from year to year in their relative frequency.[10, 11] Studies over a period of five years in Rumania and other eastern European countries show that the most constant high percentage of scarlet fever is caused by Type 10, although there are fluctuations in relative preponderance.[12] It may be that during these years in the Balkan countries scarlet fever was in an epidemic phase in which Type 10 was a highly effective invader and rash producer. In England, the disease may be more in an endemic or perhaps interepidemic phase, with four effective strains, Types 1, 2, 3 and 4, causing most of the disease, yet with no one of these types acting as a truly epidemic strain on a wide scale. Patterns differ in other countries, and in North America the typing evidence suggests a sporadic appearance of predominant scarlet fever types. It may be that the relative mildness of the disease in recent years in this country is reflected in the variety of types associated here with scarlet fever. On the other hand, the emergence of a single type associated with a high percentage of cases may be an indication of scarlet fever in a severe epidemic form.

The geographic limits of a type pattern in scarlet fever are yet to be defined. There is some suggestion from Table 4 that the patterns are fairly widespread. Other studies on throat cultures in normal population groups show similarities of streptococcus-type patterns that fluctuate only in relatively large units of time and space.[27]

Circumscribed outbreaks such as occur in institutions or from such accidents of environmental sanitation as the contamination of raw milk may not

TABLE 4. *Percentage Distribution of Predominant Types of Hemolytic Streptococci in Scarlet Fever in the United States and Canada.*

STUDY	YEAR	NO. OF CASES TYPED	PREDOMINANT TYPES FIRST		SECOND		THIRD		PERCENTAGE OF PREDOMINANT TYPES
Community surveys:									
Binghamton, N. Y.[13]	1939–1940	21	19*	(53%)	6	(10%)	—	—	63
Baltimore, Md.[13]	1937–1938	105	3	(22%)	4	(13%)	2	(10%)	45
Baltimore, Md.[14]	1940	39	19	(15%)	8	(15%)	6	(15%)	45
Chicago, Ill.[15]	1934–1935	243	3	(25%)	6	(22%)	2	(21%)	68
New Haven, Conn.[16]	1940–1941	11	3	(100%)	—	—	—	—	100
San Francisco, Cal.[17]	1941	15	11	(40%)	25	(27%)	—	—	67
Toronto, Canada[18]	1940–1941	88	1	(21%)	2	(19%)	3	(19%)	59
Halifax, Canada[19]	1941	57	19†	(37%)	30	(26%)	3	(12%)	75
Ottawa, Canada[20]	1940–1942	907	3	(56%)	19†	(12%)	4	(8%)	76
New Haven, Conn.[21]	1943	3	14	(100%)	—	—	—	—	—
Milk-borne and food-borne outbreaks:									
Massachusetts[22, 23]	1942	9	2	(100%)	—	—	—	—	100
New York State[24]:									
Wellsville	1936	?	3	—	—	—	—	—	—
Owego	1936	?	15†	—	—	—	—	—	—
Pultney	1941	4	3	(100%)	—	—	—	—	100
Cannonsville	1942	?	3	—	—	—	—	—	—
Military surveys:									
New England area (military training camp)[13]	1941	36	1‡	(67%)	17	(8%)	8	(8%)	83
Illinois area[25]	1941–1942	23	26	(40%)	18	(26%)	14	(26%)	92
	1942	2	11	(100%)	—	—	—	—	—
Kentucky area[25]	1942	8	17	(50%)	4	(25%)	24	(13%)	88
Wyoming area[25]	1942	45	19	(89%)	11	(5%)	15	(2%)	96
Western area[26]	1943	75§	19	(100%)	—	—	—	—	—
Middle-western area[27]	1943	95	3	(36%)	19	(33%)	17	(15%)	84
Canada (military recruits)[20]	1940–1942	50	19†	(52%)	3	(18%)	6	(16%)	86
New York (naval recruits)[28]	1942	72	19	(98%)	—	—	—	—	98
Maryland (naval recruits)[29]	1943	38	3	(55%)	19	(37%)	1	(5%)	97

*Weak cross reaction with Types 4, 24, 26 and 29.
†Cross reactions with Types 17 and 23.
‡Weak cross reaction with Type 1.
§Approximate; all cases same type.

always be caused by the prevailing types in the community. In the same way, closely herded communities, such as Army and Navy training stations may show predominating types different from those of the surrounding population. Such differences between military and civilian types may have epidemiologic importance at the present time. If the semi-isolated military community finds scarlet fever and streptococcal disease caused by the same types as in the surrounding population, the problem of control is shared with those outside. If the streptococcus-type flora is indigenous to the camp, the indications for control lie in the environment within the compound.

Summary

Types of hemolytic streptococci associated with scarlet fever in certain Massachusetts cities during 1942 and 1943 were predominantly Types 2, 1, 8 and 19 in that order of frequency. During this period there was some shifting of type in relative order of frequency among the predominant types, although Type 2 maintained itself as a major cause of scarlet fever.

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POLYARTHRITIS IN SICKLE-CELL ANEMIA*

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BOSTON

SICKLE-CELL anemia has long been known to simulate rheumatic fever. Huck[1] was the first to describe cardiovascular involvement in this form of anemia, and King and Janeway[2] have emphasized electrocardiographic changes similar to those found in rheumatic fever, such as prolongation of the PR interval. Klinefelter,[3] in a summary of the present knowledge of the heart in sickle-cell anemia, noted at autopsy the absence of valvular disease in patients who had died of sickle-cell anemia and heart failure. Although on the whole little attention has been paid the heart pathologically, mention has been made of myocardial scars, flabbiness of the muscle and enlargement of the right ventricle (Bauer[4]).

Despite the fact that the high incidence of combined cardiovascular disease, joint pain and fever in sickle-cell anemia is stressed in publications from the South (Wintrobe[5] and Bauer[4]), the frequent occurrence of these symptoms in Negroes living in the northern states has attracted scant attention. Because of the prevalence of true rheumatic fever in Whites as well as in Negroes in the North, the diagnosis of rheumatic fever is always uppermost in the mind of the physician when a young Negro complains of joint pains in a febrile disease of unknown etiology. This is particularly regrettable since sickle-cell anemia, once considered, can be easily demonstrated by a sealed wet preparation of the blood. In 3 of the 4 cases reported herein the correct diagnosis was missed because such preparations were not made. Wet preparations should, therefore, be included in the examination of any Negro with symptoms suggesting rheumatic fever, regardless of the presence or absence of anemia. In one of the patients (Case 3), sickle-cell anemia was considered and wet preparations were studied. When sickling did not occur after twenty-four hours, the diagnosis was abandoned. Further studies revealed that in this case the tendency to sickle did not appear until forty-eight hours had elapsed, and it was later found necessary to observe these preparations for at least ninety-six hours.

The following is a summary of 4 cases of sickle-cell anemia found among 16 Negroes whose illness had been erroneously diagnosed as active or inactive rheumatic fever.

Case Reports

Case 1. T. L., a 12-year-old Negress, at the age of 5 began to have prolonged episodes of low-grade fever, frequently associated with shorter periods of pain in the muscles and joints. At other times she had vague abdominal pain. In July, 1941, when such an episode was observed by the district physician, a diagnosis of rheumatic fever was made. After 1 month of bed rest an inconstant, soft systolic murmur was heard at both apex and base. The patient returned to school 5 months later and was seen regularly in the Outpatient Department, where a wet preparation of the blood showed sickling after 96 hours. Some weeks later, the sickling was found to be immediate. The heart was normal by x-ray. The electrocardiogram showed sinus arrhythmia, with P_1 and P_2 upright, P_3 inverted, a PR interval of 0.12 second, a QRS complex of 0.06 second, T_1 upright and T_4 inverted, thus being within normal limits for this age. The lowest hemoglobin found was 67 per cent, the lowest red-cell count 3,570,000 and the white-cell count 6300. The blood sedimentation rate was normal.

Case 2. J. H., a 12-year-old Negress, at the age of 7 was found to have a cardiac murmur. At times she had pain in the thighs. Intermittent icterus of the scleras, not associated with other signs of illness, had been observed by the mother since the age of 9. In 1939, the patient was hospitalized because of an attack of acute abdominal pain, considered by her physician to be caused either by appendicitis or by rheumatic fever. A blood test, however, showed sickling, and a diagnosis of sickle-cell anemia was made. Thereafter the patient was not again under medical observation until March, 1942, when she was examined for acute pharyngitis. A rough apical systolic murmur was heard at that time. A wet preparation of the blood showed marked sickling. The blood sedimentation rate was normal (3.5 mm. per hour). X-ray examination of the chest showed the heart to be definitely enlarged to the left. The electrocardiogram read as follows: P and T upright, Q_3 3 mm., QRS complex normal, PR interval 0.18 second and Lead 4 normal. The hemoglobin was 57 per cent, the red-cell count 2,700,000, and the white-cell count 15,000, with 46 per cent polymorphonuclear leukocytes, 22 per cent lymphocytes, 13 per cent monocytes, 18 per cent eosinophils, and 1 per cent basophils. The icteric index was 25.

Case 3. B. M., a 27-year-old Negress, enjoyed fairly good health until the age of 25, when she suddenly developed fatigue, dyspnea on exertion and dizziness. Because of a history of "rheumatism" 10 years before, a blood pressure of 155/105 and a short, rough apical systolic murmur, a diagnosis of rheumatic heart disease was made. Anemia was present at that time, — the red-cell count was 4,550,000 and the hemoglobin 55 per cent — but was attributed to a persistent menorrhagia. A blood Hinton test was negative, although 4 years previously the patient had contracted syphilis and had received 12 months' treatment. Ferrous sulfate caused moderate improvement, both symptomatically and in the blood picture. The patient ceased coming to the clinic after 4 months. On readmission 1 year later, hypochromic anemia and hypertension were again present. A wet preparation of the blood showed sickling. The hemoglobin was 50 per cent, the red-cell count 4,080,000, and the blood sedimentation rate 20 mm. per hour. An electrocardiogram showed sinus rhythm with ventricular extrasystoles. P_1 was flat, P_2 and P_3 upright, T_1 flat, T_2 and T_3 low, and R_4 inverted; the PR interval was 0.20 second, and the QRS complex 0.06 second. This was considered suggestive of myocardial damage. X-ray examination showed a normal outline of the heart.

Case 4. L. D., a 28-year-old Negress, was first seen because of headaches of long standing. She stated that she had had two episodes of moderate joint pain without swelling 3 and 10 years previously, but did not recall whether fever had been present. Physical examination revealed a normally developed girl with definite pallor but no jaundice of the mucous membranes. The joints were normal. There was dyspnea on moderate exertion, and at the apex there was a loud Grade II systolic murmur, transmitted to the axilla. The heart was not enlarged either by percussion or x-ray; the rhythm was regular and the blood pressure 110/60. A

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few rales were present over both lung bases. The hemoglobin was 65 per cent, and the red-cell count 3,560,000, and the white-cell count 15,000, with 58 per cent polymorphonuclear leukocytes, 25 per cent lymphocytes, 14 per cent monocytes, 2 per cent eosinophils and 1 per cent basophils. The blood sedimentation rate was 5.0 mm. in 1 hour. Blood Hinton and Wassermann tests were negative. A catheterized urine specimen contained 0.05 per cent of albumin. Blood smears revealed moderate sickling in stained and marked sickling in wet preparations after several hours.

Discussion

Three of these 4 patients had had more or less severe joint pain in the past, but in none was there any residual damage in the joints. Vague muscle pain in the thighs and arms, unassociated with actual joint pain, had also been present. Since none of the patients were observed during an acute febrile episode with joint pain, it was impossible to check on the observation of others that salicylates, in contrast to their effectiveness in acute rheumatic fever, have only slight analgesic effects in sickle-cell anemia.

At the time of examination signs of cardiac embarrassment were not present except for slight dyspnea on exertion in Cases 3 and 4. One physical finding suggesting mitral-valve disease was present in all patients, namely, a loud systolic murmur, localized over the apex and transmitted to the axilla. In 3 patients, the murmur was louder than one would expect from the degree of anemia present; a thrill was not present. Slight enlargement of the left ventricle was present in 2 patients. A diastolic murmur was not heard in any patient but has been reported by Klinefelter[3] and others. A systolic murmur over the aorta was present in Case 4. Slight prolongation of the PR interval was found in Case 4, and the general electrocardiographic picture was that of myocardial damage.

All the patients showed marked hypochromic anemia not responding to iron. The blood sedimentation rate was normal in 3 patients and slightly elevated in 1. Although this was not ascertained during acute attacks, a normal rate, if found during relapses, may prove of great aid in ruling out acute rheumatic fever. Such a rate is in conformity with experiments conducted by Bunting,[6] who showed that sickle-shaped erythrocytes do not settle so fast as do normally shaped ones. In other patients, particularly extremely sick ones, elevated blood sedimentation rates have been observed.

Although only the diagnosis of sickle-cell anemia alone could be established in our cases, the possibility of a combined occurrence of rheumatic fever and sickle-cell anemia should be kept in mind. In the absence of a mitral diastolic murmur, enlargement of the heart (mainly to the left) without characteristic configuration and a slow sedimentation rate, there is little likelihood of the presence of rheumatic fever. According to experienced observers, such a coincidence is extremely rare. Klinefelter[3] mentions only one doubtful case. Walker and Murphy[7] recently published a case verified by autopsy. Such a combination should be kept in mind, although for practical purposes it is improbable.

The well-known observation that heart failure frequently occurs in sickle-cell anemia remains to be explained. Most patients de either from heart failure or multiple thromboses. The tendency to thrombosis may lead to coronary occlusions, and the presence of myocardial scars in such cases may be due to myocardial damage following arterial thrombosis. Bauer[4] stresses the frequency of right-sided failure due to thrombosis of the pulmonary vessels. Several such cases with terminal cor pulmonale are on record.[8]

Summary

Four cases of sickle-cell anemia are discussed in which the diagnosis was obscured by the presence of polyarthritis and heart murmurs simulating rheumatic fever.

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MEDICAL PROGRESS

RECENT ADVANCES IN SURGERY (Concluded)*

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BALTIMORE

HYPERPARATHYROIDISM

THE first successful operation for removal of a parathyroid tumor was performed by Mandl,[34] of Vienna, in 1925. This patient had von Recklinghausen's disease, and improvement in the condition of the bones followed. This observation was instrumental in altering the previously held concept that the parathyroid enlargement was secondary to the disease of the bones. The view was then held for several years that the parathyroid hormone acted primarily on bone and that any significant disorder of hormone production must result in changes in the bones. Following the preparation of parathyroid extract by Collip, the pathologic physiology of hyperparathyroidism could be approached and was clarified. The working out of the clinical picture was done at the Massachusetts General Hospital by Albright, Aub, Bauer and others, and the frequent association of urinary calculi with hyperparathyroidism was noted and studied. These and other observations led to the establishment of the fact that the disorder in hyperparathyroidism is primarily one of metabolism.

As a result of careful diagnostic studies by the medical staff and of the excellent procedures devised by Churchill and Cope for identification and removal of abnormalities of the parathyroid glands, 67 patients[35] with a proved diagnosis of hyperparathyroidism were operated on at the Massachusetts General Hospital in the years 1932 to 1942. The majority of these patients had renal calculi and no demonstrable disease of bone. As to the frequency of hyperparathyroidism in association with renal stones, the following statement of Cope[36] is of interest:

> Both Fuller Albright and I are agreed in the impression that approximately 15 per cent of patients with renal stones in this part of our world have hyperparathyroidism as the cause of these stones. In only a few of these cases is the disease so marked that it can be picked up either by presence of bone disease or by one blood examination. Persistent effort and care are necessary to weed out the patients with hyperparathyroidism. A number of blood examinations have to be made and the patient is often followed for quite a while before the diagnosis is finally established.

The surgical treatment of this disorder will not be discussed in detail, but it is well to emphasize the fact that the problem is concerned with the site as well as the size of the tumor or hyperplasia. The parathyroid glands, whether adenomatous, hyperplastic or uninvolved, have been found in various locations between the larynx and the heart. In approximately 20 per cent of the cases at the Massachusetts General Hospital the adenoma has been in the anterior or posterior mediastinum. The procedure recommended by Cope[37] is as follows: At the first stage the neck and the posterior mediastinum are explored through a supraclavicular incision. If the offending gland or glands are not found, the anterior mediastinum is explored through a median sternotomy at another operation. It is well to remember that all the glands may be hyperplastic. Visualization of the parathyroid glands in such cases should be followed by total removal of three and subtotal resection of the fourth. The finding of one adenoma does not mean that others may not be present. It is desirable whenever possible to locate all the glands.

The mortality rate with this operation has been low and the results in general have been excellent. Cope[36] states that there has been no further formation of stones in the urinary tract in patients with corrected metabolism. In patients with lesions of bones, a thick wall of bone is deposited around the cyst so that the bone is strengthened but the cyst does not disappear. In addition, several patients with severe anemia have shown decided improvement. The development of this entire subject represents a brilliant accomplishment, particularly on the part of the staff of the Massachusetts General Hospital.

THE THYMUS GLAND AND MYASTHENIA GRAVIS

Nothing is known about the function of the thymus gland and little about the pathogenesis of myasthenia gravis. It is known that a significant percentage of patients with myasthenia gravis have been found by roentgenography, operation or autopsy to have a tumor of the thymic region. The lesion is usually benign, and is rare in patients who do not have myasthenia gravis.

The results that followed the removal of benign thymomas from patients with myasthenia gravis encouraged Harvey, Ford, Lilienthal and myself[38] in July, 1941, to determine the effect of total thymectomy without regard to the presence or absence of a tumor. This was the first time that the effect of total removal had been studied in man. Since July, 1941, we have removed the thymus gland

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from 20 patients with myasthenia gravis. Only 2 of these patients had a thymoma. The results may be divided into five groups.

Four patients have died since the operation. In 3 cases death occurred within four days. In 2 of these, the patients were extremely ill at the time of operation and the procedure was carried out as a last resort. One patient died eight months after the operative procedure, having shown no improvement as a result of it.

Three of the remaining 16 patients are well or essentially well. Two of these have shown sustained improvement for more than two and a half years. One of the 3 patients had a thymoma.

Five patients are considerably improved. The dose of prostigmine has been very much reduced and the patients' general condition is much better than it was previously.

Five patients have shown slight improvement.

Three patients have exhibited little or no improvement.

The experience of Keynes and Carson[39] has been similar to ours. At the time of their report in 1943, thymectomy had been performed on 12 patients, and it is said that the series has now been extended to 25 cases.

Since some patients with myasthenia gravis have spontaneous remissions and since the results following thymectomy are not uniform, it is difficult to judge of the effects of this operative procedure on the course of the disease. The impression is gained that the removal of the thymus gland has been the cause for the improvement in a number of cases. Unfortunately, there are at present no means available for determining preoperatively which patients will be benefited by the procedure. Until further information is available, it appears that thymectomy should be performed only on patients with a severe degree of myasthenia gravis in whom the response to prostigmine medication is unsatisfactory.

Patent Ductus Arteriosus

Although it has been only a few years since Gross[40,41] first successfully occluded a patent ductus arteriosus, the procedure has been accepted without reservations and is a noteworthy accomplishment. That this lesion is not a rare one is demonstrated by the fact that Gross[30] alone has operated on 65 persons with this abnormality. In fact, Keys and Shapiro[42] estimate that there are approximately 20,000 people in the United States with an open ductus.

Since it has been demonstrated that this operative procedure can be performed with a low mortality rate, the indications for operation have been somewhat extended. The most conservative probably agree with Gross[30] that there are at least three definite indications for operation: when the patient is not developing properly in physical stature; when there is any evidence of cardiac fatigue; and when there is superimposed *Streptococcus viridans* infection without evidence of peripheral emboli. Credit is due Touroff[43] for his work in establishing the value of operation in patients with endarteritis. In addition to the above-mentioned three groups, there remains a group of patients who are getting along well except for the constant danger of a future infection with *Str. viridans*. It is estimated by Gross[30] that such patients face a risk possibly as high as 25 per cent of having a serious infection in the future. In addition to the danger of endarteritis, the open ductus in such patients may be causing symptoms that are not noted. The studies of Keys and Shapiro[42] show that patency of the ductus arteriosus after the age of seventeen is associated with an average reduction in life expectancy of about twenty-five years. Gross[30] has this to say about the results of operation on those patients who have been relatively free of symptoms:

> I have been increasingly impressed by the statements of some of these patients after operation. Many of them have volunteered the information that. . . whereas they had no complaints before operation, . . . they now feel much better than they did previously; they have an increased vigor, their breathing is easier, their energy is greater and so forth. In other words, their circulation has been improved and they have become conscious of the change.

The frequency with which this operative procedure will be performed in the future will be influenced to a considerable extent by the success or failure of penicillin or some similar agent in the treatment of infection due to *Str. viridans*. Even if such infection does respond to penicillin, there will still be many patients with a patent ductus in whom operation is indicated.

From the viewpoint of operative technic, the main question at present is whether one should simply ligate the ductus or whether it should be completely divided and closed. Gross[44] now favors the latter course. Division and closure of the ductus is a better surgical procedure, but at the same time it is a difficult and rather dangerous operation.

Wiring and Electrothermic Coagulation of Aneurysms

It has been approximately eighty years since the first attempt was made to wire an aneurysm, and it has been fifty-six years since Matas first performed his procedure known as "endo-aneurysmorrhaphy." As regards improvements in methods for wiring aneurysms, the advances that have been made by Blakemore and King[45] have not been fully appreciated. Their procedure is so different from those used previously that it cannot be considered as in the same class, and this contribution rates as one of the greatest in surgery in the last decade. Most aortic aneurysms should be treated by this method, as should peripheral aneurysms on an arteriosclerotic basis in the older age group.

It has long been known that a saccular aneurysm that is filled with clot — "Nature's cure"— may remain inactivated indefinitely. Blakemore and King have pointed out that blood circulating under pressure creates a strain on the wall of a saccular or fusiform aneurysm that varies with the square root of its surface area. A doubling of the diameter of an aneurysm by growth increases the total strain on the sac wall by 100 per cent. On the other hand, a blood clot, behaving according to the physical laws governing solids, reduces the strain on the sac wall of an aneurysm in strict accordance with the amount of fluid blood it displaces. The degree of clotting obtainable in an aneurysm depends, other things being equal, on the rate of blood flow through the aneurysm and the presence of an abundant clot-stimulating surface. Measurements of rate of flow in saccular aneurysms of equal size may vary as much as 300 per cent depending on the size of the mouth.

In the Blakemore and King's electrothermic method of coagulating aneurysms, fine, insulated coin-silver wire is introduced through a needle into the aneurysm in 10-meter segments. The protruding ends of a segment are connected with a direct current so regulated and calibrated against changes in electrical resistance of the wire on heating as to afford an accurate measurement of the temperature of the wire at all times and the rate of blood flow through the aneurysm on initial heating. Each segment of wire is finally heated to 80°C., which results in the deposit of a tenacious clot. On the basis of the number of amperes of current required to heat the first 10-meter segment to 80°C., it is possible to determine the variety of aneurysm (based on rate of flow) and approximately the number of segments that will be necessary to impede the blood flow to the point of occurrence of mass clotting. Blakemore and King have arteriographic evidence and proof from autopsy examinations that "brim-full" clotting can be obtained by this method in saccular aneurysms in which the diameter of the mouth does not exceed that of the sac. Experience so far has shown that this group behaves clinically as do cases of "Nature's cure." Experience with the method in treating syphilitic aneurysm of the thoracic aorta of the high-velocity, cup-shaped, saccular and fusiform varieties, although not showing a cure, indicates that clotting is frequently obtained to the degree of relieving strain on the sac sufficiently to permit the strengthening processes within the sac wall an opportunity to become effective. Particularly is this true in patients under forty-five years of age who are relatively free of arteriosclerosis. This is attested by the fact that several patients have remained symptom free for several years spent at hard labor in shipyards and munition factories. Aneurysms of the abdominal aorta of this type, including the arteriosclerotic fusiform aneurysm, may be inactivated by occluding the aorta from within by wiring in two or more operative stages. The method affords a means of controlled clotting for gradual obliteration of the arteriosclerotic popliteal aneurysm without the complication of gangrene.

In the five-year period 1935 to 1940, Blakemore[46] used his method on 26 patients with syphilitic aortic aneurysm. Nine of these patients are alive, an average interval of seven years having elapsed since the operative procedure. The thoracic aorta was affected in 7 cases and the abdominal aorta in 2. Survival periods of the remaining patients ranged from a matter of hours up to eight years. The patient who survived for the full eight years had a fusiform aneurysm of the ascending aorta; he worked in a munition plant until four weeks preceding death, which was due to bronchial erosion and infection, with secondary hemorrhage. Following the wiring procedure nearly all the patients were relieved of their pain. In the absence of infection there has been only one rupture of the sac following the wiring in Blakemore's total series of more than fifty aortic aneurysms.[46] This is in sharp contrast to the high incidence of rupture — approximately 30 per cent — that accompanied the employment of the previous methods. Since poor risks were not excluded and since the patients had an associated syphilitic infection that in itself might have been fatal, the results appear to be encouraging. It is obvious that procedures such as blocking the sympathetic nerves should be used in association with the wiring procedure when indicated.

It should again be emphasized that the Blakemore operation is not the procedure of choice in all cases; for example, most peripheral syphilitic aneurysms should be treated by the Matas method. In summary, wiring and electrothermic coagulation may be used to inactivate syphilitic saccular aneurysms of the aorta, to slow the growth of high-velocity, cup-shaped and fusiform aneurysms of the thoracic aorta and to cause total occlusion of aneurysms of the abdominal aorta as well as to treat some of the peripheral ones.

Blood-Vessel Anastomoses

In the present war better means for preventing and controlling infection have made it safer to defer the amputation following injuries to extremities until the nutritional status of the part can be determined. Unfortunately, a number of the reports thus far show that the incidence of gangrene is higher than it was in the last war. This is probably due in the main to the more severe injuries that result from the destructive agents that are being employed. Although sympathetic block is of some value in increasing the circulation to an extremity in which the main vessels have been severed, there is frequently serious damage to the collateral vessels as well, and the benefit that results from blocking the sympathetic nerves and from the use of papav-

erine is not sufficient to prevent gangrene. The importance of this problem of gangrene and amputation has been appreciated by Blakemore and his associates, and their studies on this subject are of great interest. Eighty per cent of all wounded men in World War I had injuries of the extremities, and the extensive use of land mines and fragmentation shells at present indicates that the incidence in this war will continue to be high.

Blakemore, Lord and Stefko[47, 48] have devised a nonsuture method for anastomosing the ends of severed arteries that consists in using vitallium tubes as a prosthesis for vein grafts. Long defects in vessels may be bridged. The method is simple and the anastomosis can be performed quickly. A moderate disproportion between the diameter of the vein graft and that of the artery does not prevent a successful result. It has been shown that preserved veins that have been prepared by quick freezing in a mixture of alcohol and dry ice and kept in the frozen state function effectively as grafts. Furthermore, homotransplants of vein grafts as well as autotransplants serve to prevent the development of gangrene.

Blakemore, Lord and Stefko[47] have had remarkable success in the experimental use of their method in conjunction with débridement and chemotherapy in badly contaminated wounds. The severed femoral arteries of dogs were repaired by use of the vein graft twenty-four hours after the vessels had been ligated and divided without aseptic precautions. Despite the fact that contamination was present and that anticoagulants were not used, 85 per cent of the anastomoses remained patent. Clinical experience with the method has confirmed the experimental observations. The relative freedom of the method from complications is thought to be due to the nonirritating qualities of the vitallium and to the fact that, since no sutures are used, the flowing blood comes into contact only with intima. It is evident that many extremities that would otherwise be lost can be saved by the employment of this method.

Blakemore[49] emphasizes the importance of including the use of heparin in the program for handling the wounded extremity with damage to the main artery. After good hemostasis has been obtained, preferably without the use of a tourniquet, measures for the control of blood clotting should be instituted in order to preserve the patency of undestroyed collateral vessels. These measures include the injection of 10 mg. of heparin — together with 50,000 units of penicillin — into the distal end of the severed and ligated main artery and the subcutaneous injection of 150 mg. of heparin in Pitkin's menstruum (Loewe's method). The clotting time is thereby prolonged for forty-eight hours.

In connection with the problem of the saving of injured extremities, the studies of Allen,[50] Brooks and Duncan[51] and others on the effects of temperature on the survival of anemic tissues are of great importance. It has been shown that cooling a part with impaired circulation is effective in delaying or preventing the onset of gangrene. There seems to be no doubt that harm may result from surrounding an extremity with defective circulation by containers filled with hot water.

Thus it seems that the treatment of severe injuries of extremities with destruction of part of the main artery should include careful hemostasis, treatment of shock, débridement, chemotherapy, relief of vasospasm by papaverine hydrochloride and sympathetic block, heparinization, cooling of the part and bridging of the defect in the artery, if such is present, by Blakemore's nonsuture method, which employs a vitallium tube lined by a vein. Irrespective of the extent to which one is able to attain the ideal in the treatment of war wounds, the opportunity is certainly available for improvements in the therapy of wounds that are seen in the civilian practice of surgery.

Autonomic Nervous System

An excellent review of progress in surgery of the autonomic nervous system was recently presented by White,[52] and the reader is referred to it for details. As White has stated, in no other field is the surgeon more indebted to the contributions of the anatomist and the physiologist. Only the advances in the treatment of peripheral vascular disease and of hypertension will be considered, and the review by White will be quoted freely.

Sympathectomy in Peripheral Vascular Disease

Raynaud's disease. The generally accepted explanation for the typical advanced case of Raynaud's disease is that proposed by Lewis[53]; namely, that the phenomena of intermittent color changes in the digits are due to abnormal contraction of the arterioles in direct response to cold. The most interesting therapeutic problem is connected with the fact that vasoconstriction is nearly always abolished in the lower extremities after resection of the lumbar ganglia, whereas such was frequently not the case in the upper extremities after resection of the upper dorsal ganglia. It has been shown in man that the highest vasoconstrictor fibers to the upper extremity emerge in the second thoracic nerve and are present in each succeeding anterior root down to the ninth or tenth thoracic level. The difference in the earlier results with upper dorsal and with lumbar sympathectomy seems to have been explained satisfactorily on the basis that postganglionic fibers were interrupted in the dorsal region and preganglionic fibers in the lumbar region. The second and third lumbar ganglia carry only preganglionic fibers to the sciatic nerve, and their removal produces a defect of sufficient length to prevent regeneration. The sympathetic vasoconstrictor fibers must be

completely interrupted; otherwise the secretion of sympathin at their endings is capable of exciting contraction in all the denervated smooth-muscle cells in the vascular walls. Smithwick[54] has described an excellent method for preganglionic sympathectomy of the arm and for the prevention of regeneration. He advises division of the chain below the third thoracic ganglion and intradural division of the second and third thoracic anterior spinal roots so that their subsequent growth will be checked by the intact dura. The mobilized upper portion of the trunk is covered with a cylinder of fine silk and the free end is transplanted into the muscles of the back in order to prevent reconnection of the divided ends. Despite all precautions, recurrence of vasoconstrictor tone occasionally takes place, but it can be stated that the results are much better now than previously.

Other types of vascular disease. In occlusive vascular disease of the extremities there may be superimposed vasospasm that is the deciding factor in leading to gangrene. It is important to realize that sympathectomy may bring about decided improvement even though preliminary tests do not indicate that such would be the case. Trimble,[55] Shumacker[56] and others have reported the cases of a number of patients with uncomplicated arteriosclerosis who have been benefited by sympathectomy. There is frequently a large element of vasospasm in thromboangiitis obliterans, and sympathectomy is often helpful. This procedure may be combined with the crushing of peripheral nerves. The use of sympathetic block in the treatment of thrombophlebitis was considered by Ochsner[57] in a previous Shattuck Lecture. Ligation of the major arteries of extremities had best be accompanied by measures that result in a local abolition of vasoconstrictor tone. In this manner the incidence of gangrene can be greatly lessened.

Sympathectomy in Essential Hypertension

Even though sympathectomy has distinct limitations in the treatment of hypertension, there is no doubt that there are many patients who have been definitely benefited. Only an occasional patient over fifty years of age is a suitable candidate for this procedure. Sympathectomy should not be performed when both cardiac and renal functions are significantly impaired. Grimson[58] has pointed out that the lowering of the blood pressure is usually directly proportional to the extent of the sympathectomy and inversely proportional to the severity of the disease. Four general types of operative procedures are in current use: supradiaphragmatic ganglionectomy and splanchnicectomy, as described by Peet[59]; the subdiaphragmatic operation of Allen and Adson[60]; the combined thoracolumbar sympathectomy of Smithwick[61] and the total sympathectomy of Grimson.[62] The first two procedures do not completely denervate the lower part of the body. There has not been sufficient experience as yet to determine whether the more radical procedure of Grimson produces better results than does that of Smithwick. The latter procedure has yielded excellent results, and at present it appears to be the operation of choice. No doubt Smithwick's good results can be explained in part by a careful selection of patients.

Despite much work in recent years on the etiology of hypertension, understanding of the condition in man remains extremely inadequate. There is not even certainty as to the manner in which sympathectomy exerts its beneficial effects. The likeliest explanation is that there is a general reduction of the tone of smooth muscle in the denervated vascular bed.

The Pancreas

In the past the main deterrent to operations on the pancreas was the unfounded but firm conviction on the part of surgeons that operative trauma to the pancreas was fraught with great danger of producing acute pancreatitis, which in itself entailed a high mortality. It is indeed difficult to understand how this conception gained such widespread adoption in view of the fact that throughout the past decades cases of incision of the pancreas with excision of tissue, but without the production of pancreatitis, were reported in the literature from time to time.

Recent years have witnessed the development of the surgery of pancreatic tumors. The surgery of pancreatic inflammations has received relatively less attention because of the rarity of these conditions. The advent of the blood amylase test for acute pancreatitis has resulted in an improvement in diagnosis. Experience indicates that acute primary hemorrhagic pancreatitis is probably best treated conservatively rather than by operation and drainage of the region, as was the custom in the past when such a diagnosis was made.

In regard to the surgery of pancreatic tumors, the important factors in its development were the description of the syndrome of hyperinsulinism due to islet-cell adenomas and the spectacular cures obtained by their excision; the ever-increasing boldness of surgeons in extending surgical attack on intra-abdominal cancer, and the realization that survival is possible in man without the duodenum and the head of the pancreas, with consequent occlusion of external pancreatic secretion. As regards the second of these factors, advances in the understanding of surgical shock, the use of vitamin K and an appreciation of the importance of the nutritive state of the surgical patient have contributed to the feasibility of procedures that formerly could hardly have been carried out.

The following are a few of the many important contributions to this subject: the description of hyperinsulinism by Harris[63] in 1924; the report by Wilder and his associates[64] in 1927 of the first case of insulin-producing islet-cell carcinoma, which was

found to be inoperable because of metastases; the report in 1929 of the first correct preoperative diagnosis of insulin-producing islet-cell adenoma by Howland,[65] with successful extirpation by Graham; the paper by Whipple, Parsons and Mullins[66] in 1935 that reported successful treatment of carcinoma of the ampulla by partial duodenectomy and excision of a wedge-shaped portion of the head of the pancreas; the report by Brunschwig[67] of the successful total extirpation of the duodenum and the entire head of the pancreas for carcinoma of the pancreas; the recent report by Priestley, Comfort and Radcliffe[68] of successful total pancreatectomy for a small-islet tumor, which interestingly enough has been followed by a relatively mild degree of diabetes; and the work of Dragstedt and his associates[69] with lipocaic. An index to the increasing frequency with which the Whipple procedure or a modification of it is being performed is afforded by the fact that Cattell[70] has performed seventeen such operations in the last several years.

Problems in operative technic at present center around procedures to reimplant the transected neck of the pancreas into the bowel. It has not yet been finally demonstrated that the successful anatomic implantation affords a functional result. There is some evidence that cicatricial occlusion of the transected neck may prevent its accomplishment. The observation in dogs that pancreatic ducts rapidly regenerate to bowel certainly does not apply in monkeys and has not been demonstrated in man.

Some persons get along normally with completely occluded pancreatic ducts and without the duodenum, others seem to lack full digestive powers for fats and protein but manage to get along well anyway, and still others also lack these powers but do very poorly. Attempts at substitution therapy for pancreatic juice are only partly successful, and here again the situation in animals differs sufficiently from that in man so that the answer can be found only by further clinical investigation.

Cancer of the body and tail of the pancreas is possibly one of the most difficult abdominal cancers that the surgeon has to deal with because it is so often "silent" until an advanced stage. Considerable experience will be necessary to permit an evaluation of what can be accomplished by these operations.

Carcinoma of the Prostate

Following the work of Gutman, Sproul and Gutman[71] and others on the prostate-phosphatase relation, Huggins and Hodges[72] treated a number of patients with advanced prostatic cancer by removal of the testes or by estrogen administration, using as a yardstick the elevated serum phosphatase levels. The reduction in androgens was accompanied by a sharp fall in the amount of acid phosphatase to or toward normal and by a slower rise of alkaline phosphatase, which subsequently likewise decreased. It was the impression of Huggins that the changes in alkaline phosphatase reflected healing in the lesions in bone. Clinical changes in some of the patients included the relief of pain, an increase in appetite, a gain in weight and a decrease in the size of the neoplasm. In several patients there has been recovery from paralysis that was due to involvement of the spinal cord or nerve trunks with cancer. Huggins[73] recently summarized the results as follows:

> It must be emphasized that the results are not uniformly successful and that they fall into three groups: one group, less than 5 per cent of patients, received no or slight benefit from endocrine treatment; the other groups, larger and nearly equal in number, obtained respectively an improvement pronounced but unsustained (less than eighteen months) or a pronounced and more prolonged regression of the disease.

In a recent personal communication Huggins stated that about 25 per cent of the patients seem to be completely free of the disease more than three and a half years after orchiectomy.

If one grants that untreated carcinoma of the prostate gland in many cases follows a peculiar course, the observations of Huggins are extremely important. His work casts doubt on the concept of autonomy of the cancer cells, since he has found that in some cases prostatic cancer is dependent on androgen for its survival. The fact that this one type of cancer is sometimes amenable to general methods of therapy encourages one to hope that the same may be true of other forms of cancer.

Rupture of an Intervertebral Disk

There is no problem that has excited wider interest and more controversy in recent years than that of the role of the ruptured intervertebral disk in the causation of low-back pain and sciatica. Middleton and Teacher,[74] Dandy[75] and others had described ruptured disks, but it was not until 1934 that Mixter and Barr[76] reported observations that led to an appreciation of the frequency of the condition. There is considerable difference of opinion concerning the accuracy with which a diagnosis can be made. Most observers are agreed that the introduction of radio-opaque substances into the spinal canal is rarely justified. In the last several years there have been noteworthy improvements in the operative procedure; these include a transition from a complete laminectomy with transdural removal of the disk to a unilateral exposure between the laminas, with removal of little or no bone, depending on the size of the opening, and extradural removal of the disk.[77]

There is no doubt that ruptured disks do occur, and the wide differences of opinion have to do with the frequency of occurrence and the certainty with which an accurate diagnosis can be made. Time and further experience will show that the truth lies between the very reserved position that is taken by most orthopedists and the much more enthusiastic concept that is held by some neurosur-

geons. In the meantime, the neurosurgeon as well as the osteopath has invaded the field of the orthopedic surgeon, and this is probably a good thing for all concerned, including the patient.

In the future every effort will undoubtedly be made to explain the failure to relieve symptoms that is noted following some of these operations. Another problem of interest is the role of the cervical intervertebral disk as a cause of brachial neuritis in the absence of compression of the spinal cord. Mixter's[78] opinion on this subject is as follows:

> I believe we shall hear more of it in the future and that the number of cases operated on will increase. The problem is still in its infancy, but the number of cases that have been operated on during the past ten years means that it is a real entity and one of considerable importance.

This statement is supported by a recent article by Spurling and Scoville.[79] These problems will be of particular importance in the post-war era.

* * *

As indicated previously, the advances in surgery are so numerous that one can consider only a few of them in a limited time and space. I have chosen those problems that seem of particular interest to me at the moment, and it is likely that others would select an entirely different list. Included among other contributions that might have been considered are the following: the compression treatment of burns; the Orr–Trueta treatment of open wounds and compound fractures; the use of concentrated human serum albumin and of gelatin; the development of thrombin, fibrin foam, and fibrin films; the use of heparin and of dicumarol; the intraintestinal use of poorly absorbed sulfonamides, such as sulfaguanidine and succinylsulfathiazole; the introduction of thiouracil for the treatment of hyperthyroidism and the preoperative preparation of patients who do not respond to iodine; the development of mechanical dermatomes; improvements in transurethral prostatectomy; concentration radiotherapy in the treatment of cancer of the larynx; irradiation of adenoid tissue in the prevention and treatment of deafness; studies on the Rh factor; the recognition and treatment of intracranial aneurysms; the diagnosis and treatment of tumors of the adrenal cortex and medulla; the treatment of Addison's disease by the subcutaneous implantation of pellets of desoxycorticosterone acetate; the intracranial approach to orbital tumors; improvements in mechanical devices for treating fractures; the development of methods that are aimed at stimulating the collateral blood supply to the heart; studies on the pathogenesis and treatment of blast and crush injuries; improved methods for nerve anastomosis; additional methods by which skin grafts may be held in place; the use of vitamin K; the wide employment of tetanus toxoid; and the use of vitallium tubes in the anastomosis of ducts. Even this long list could be extended almost indefinitely.

One of the most gratifying features of surgery is that the solution of one problem simply opens up additional problems. Churchill[80] in discussing renal failure in association with injuries stated recently, "It has always fascinated me in clinical surgery to see that as one or more weak links in a chain are strengthened by improved methods of therapy, another weak spot is revealed that becomes recognized only because the chain holds to test it." There are numerous unsolved major problems. For example, it is now technically possible to remove various organs and parts, but it is impossible to replace these structures by those from another person. The technic for transplantation is suitable in most cases, but the part does not survive long in the new host. The solution of this problem would open vast possibilities. It is inspiring to realize that, despite the rapid progress and the many accomplishments in various fields, surgery still offers to investigators and clinical surgeons rich opportunities for work and study.

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CASE RECORDS OF THE MASSACHUSETTS GENERAL HOSPITAL

Weekly Clinicopathological Exercises

FOUNDED BY RICHARD C. CABOT

TRACY B. MALLORY, M.D., *Editor**

BENJAMIN CASTLEMAN, M.D., *Acting Editor*

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CASE 30341

PRESENTATION OF CASE

First admission. A fifty-four-year-old man entered the hospital because of severe epigastric pain.

The patient was apparently perfectly well until a few hours before entry, when he developed a sudden, severe, stabbing pain between the shoulder blades. It was soon noticed in the epigastrium, below and to the right of the umbilicus, and seemed to go through and through. The pain was constant but there were acute exacerbations. Nothing seemed to relieve or aggravate the pain. There were no other symptoms referable to the gastrointestinal, genitourinary and cardiorespiratory systems.

The past history was essentially negative except for an inguinal herniorrhaphy six years before entry.

Physical examination showed a well-developed, well-nourished, restless, slightly cyanotic man complaining of severe abdominal pain. The throat was moderately red. The trachea was in the midline. The lungs were clear. The heart was normal in size. The sounds were bounding, with frequent extrasystoles. The aortic second sound was greater than the pulmonic. The abdomen was distended, with spasm and mild tenderness in the epigastrium but without any palpable masses. There was tenderness to percussion over the lower thoracic spine. The arterial pulsations in the groins and in the feet were of equal intensity.

The blood pressure was 220 systolic, 90 diastolic, in both arms. The temperature was 98.6°F., the pulse 100, and the respirations 20.

Examination of the blood showed a white-cell count of 13,500, with 88 per cent neutrophils. The red-cell count was 5,050,000, with 17.5 gm. of hemoglobin. The urine was acid, with a specific gravity of 1.022, and gave a +++ test for albumin, a ++ test for diacetic acid and a +++ test for acetone. Three to four white cells and red cells were seen per high-power field. Several blood Hinton tests were negative.

X-ray examination of the chest (Fig. 1) showed clear lung fields. The heart shadow was at the upper limits of normal, but the apex was blunted. The aorta showed a moderate degree of tortuosity, with slight dilatation. An intravenous pyelogram was normal.

On the second hospital day the pain was less severe, and located in the epigastrium. It was somewhat relieved by 10 mg. (1/6 gr.) of morphine, together with 0.65 gm. (10 gr.) of aspirin and 30 mg. (½ gr.) of codeine. Intravenous fluids were administered. The patient had considerable sweating. He pointed to an area below and to the right of the umbilicus as being occasionally tender. On the third hospital day he complained of epigastric pain and distress. The abdomen became distended, but without tenderness or spasm. The temperature rose to 101°F. The extremities seemed cold and clammy, with profuse perspiration over the rest of the body. The lips were slightly cyanotic. An electrocardiogram revealed frequent auricular premature beats, with a rate of 80 and slight left-axis deviation. T_1, T_2, and T_3 were upright, T_4 was

*On leave of absence.

rather low, and R_4 was small and upright. The urine gave a + test for albumin, and the sediment contained 2 white cells per high-power field. The white-cell count was 19,800, with 88 per cent neutrophils. The sedimentation rate was 22 mm. in sixty minutes. Two van den Bergh tests were negative. The basal metabolic rate was normal. Plain films of the abdomen and dorsal spine and gall-bladder studies were normal. The pain was relieved by 30 mg. (½ gr.) of codeine.

During the next eighteen days the patient improved considerably, with almost complete disappearance of the epigastric pain and fewer sweats. He continued to have bilateral back pain. During that period a gastrointestinal series was entirely negative. Films of the chest, nine days after admission, showed definite dilatation of the aorta, which seemed to be more marked than in the previous examination, but whether this was due to the slight rotation of the patient or to actual dilatation could not be determined. The dilatation was most marked in the upper descending portion, where the diameter was almost twice normal. Fluoroscopic pulsations were visible in the ascending portion but not in the descending. The back pain subsided somewhat, although movement of the back aggravated the pain. The urine cleared up, the white-cell count became normal, and the pulse ranged about 70. The patient was discharged to a nursing home on the thirtieth hospital day.

Second admission (four years later). After discharge the patient retired from work but carried on active life until about two months before reentry, when, following the death of his mother, he noted marked shortness of breath and weakness on climbing stairs. He developed a sore throat. For the few weeks prior to admission he had raised considerable gas after eating. During that period he had two attacks of nocturnal dyspnea and found it necessary to use three pillows when sleeping. He had had nocturia (three or four times) but no pain, indigestion, loss of appetite, nausea, vomiting or swelling of the ankles.

Physical examination showed a well-developed, well-nourished man in no distress. The lungs were clear. The left border of cardiac dullness was 10 cm.

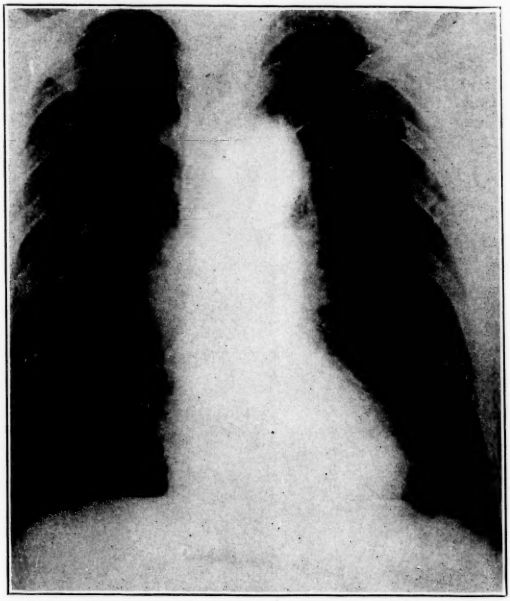

FIGURE 1.

to the left of the midline in the fifth space. The auricles were fibrillating. The abdomen was negative.

The blood pressure was 198 systolic, 120 diastolic. The temperature was 98°F., the pulse 65, and the respirations 25.

Examination of the blood showed a hemoglobin of 13.6 gm. The nonprotein nitrogen was 30 mg. per 100 cc. The urine had a specific gravity of 1.024, with a ++++ test for albumin, and the sediment contained many coarsely and finely granular casts, 20 white cells and 4 red cells per high-power field. A Hinton test in dilutions and a Wassermann test were negative. X-ray examination of the chest (Fig. 2) showed the heart markedly enlarged and particularly prominent in the region of the left ventricle. The aorta was extremely tortuous and was moderately dilated, particularly in the descending portion. A gastrointestinal series showed marked tortuosity of the esophagus, apparently due to adhesions of the esophagus to the arch. In the stomach, along the lesser curvature and opposite the angulus, a crater-like niche was sometimes demonstrated on compression. Barium passed after some delay through the pylorus, filling a rather large duodenal cap, in the center of which a 0.8-cm. ulcer crater was visible. An electrocardiogram showed auricular fibrillation, with an average rate of 70. T_1 was inverted, ST_1, ST_2, and ST_4 were sagging, T_1 and T_2 were upright, and T_4 was sagging. There was slight left-axis deviation.

The patient was given 0.1 gm. (1½ gr.) of digitalis daily, as well as 0.1 gm. (1½ gr.) of aminophyllin. He was placed on a three-stage gastric diet, with 15 drops of tincture of belladonna after meals. He did well. A gastrointestinal series sixteen days later did not demonstrate the lesion along the lesser curvature or a definite ulcer crater in the duodenum. He was discharged on the twenty-second hospital day.

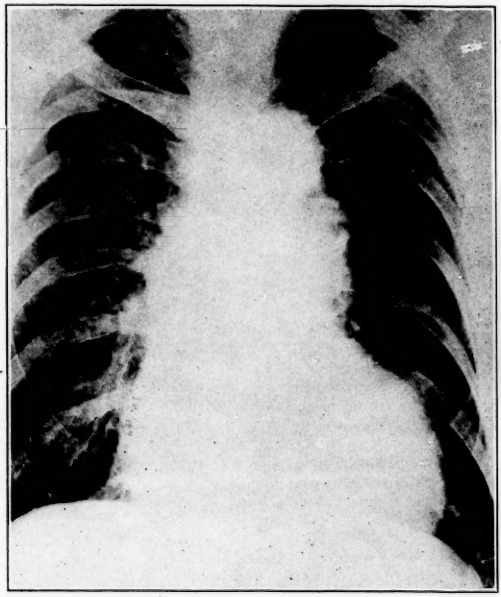

FIGURE 2.

Final admission (forty-eight days later). Following discharge the patient was asymptomatic, but one month before entry he developed diffuse lower abdominal pain that was not relieved by eating. He experienced increasing exertional dyspnea, almost nightly episodes of paroxysmal dyspnea and daily pain in the upper anterior chest. Ten

days before admission swelling of the ankles appeared and he became progressively more dyspneic. He was seen in the Emergency Ward, where additional digitalis, Mercupurine and ammonium chloride were administered, without any improvement.

Physical examination showed a restless, dyspneic man with evidence of recent weight loss. He exhibited Cheyne-Stokes respirations. The skin was cool and moist. There was dullness at the lung bases posteriorly, with decreased breath sounds and tactile fremitus. The heart was about the same size as previously; it was "fibrillating" at a rate of 82. The sounds were booming and distant, and no murmurs were heard. Mild tenderness was elicited to the right of the umbilicus. The liver was palpable two fingerbreadths below the costal margin. Marked edema of the ankles and legs was present.

The blood pressure was 170 to 140 systolic, and 95 to 105 diastolic. The radial pulse was 66, the temperature 98.6°F., and the respirations 25.

Examination of the blood showed a white-cell count of 10,000, with 82 per cent neutrophils. The red-cell count was 5,060,000, with 15.6 gm. of hemoglobin. The urine specific gravity was 1.024, with a ++ test for albumin; the sediment contained 2 or 3 red cells and an occasional white cell per high-power field. The stools were negative. The vital capacity was 52 per cent of normal.

The patient was given a six-meal bland diet without added salts. Fluids were limited to 2000 cc. One-tenth gram (1½ gr.) of digitalis twice daily, as well as ammonium chloride and Mercupurine, was administered. He perspired considerably and seemed to be improving. He was then started on 5 drops of saturated potassium iodide solution daily. In the course of the next ten days the edema almost completely disappeared and the perspiration diminished remarkably. On the twenty-first hospital day, while sitting up in bed, he suddenly clutched his chest and fell back, and died a few minutes later.

Differential Diagnosis

Dr. Paul D. White: Apparently this patient's pain at its onset was localized in one place. It came on suddenly, starting in the back between the shoulder blades, was quickly noted after that in the epigastrium, and was extremely severe. Naturally one thinks right away that the pain was probably of cardiovascular origin. The story could go with an extensive dissection of the aortic wall, which is suggested by the diffuseness of the spread of the pain and by the sudden onset without other symptoms. I have never encountered a case of myocardial infarction with pain of this distribution. Of course the acute abdominal emergencies must be considered, such as ruptured peptic ulcer, gallstones, mesenteric embolism and even renal colic. But there is no previous story of trouble in the digestive tract or in the urinary tract, and there was no vomiting. These subdiaphragmatic lesions must be borne in mind, however.

There was slight tenderness in the epigastrium and also in the back. The arterial pulsations in the groins were of equal intensity, all coming through. If there were a dissecting aneurysm of the aorta, one would expect diminished pulsations or the disappearance of the pulsation on one side or the other, as not infrequently happens. Perforation of an aneurysm into the iliac arteries would, however, permit such pulsations to be found in the leg arteries.

This man had hypertension, but there is no note of the blood pressure in the legs. The statement that the arterial pulses were apparently well felt in the legs suggests that there was hypertension there too.

There were occasional red cells in the urinary sediment, but there is no suggestion of active bleeding, such as one might expect with a renal calculus or infarct. And there was no history of hematemesis to point to a peptic ulcer.

The x-ray examination gives some indication of a hypertensive heart, but it was not very large — possibly in an early stage, with 100 gm. or so of extra weight, which produced little change.

The prolonged pain is not particularly diagnostic. We have no note about morphine on the first day.

Dr. Benjamin Castleman: He was given 15 mg. (¼ gr.) of morphine when he first entered the hospital.

Dr. White: The electrocardiogram was essentially normal. It is hardly likely that acute coronary occlusion had occurred, but the record is consistent with the other diagnoses mentioned.

There was considerable, but not extreme, leukocytosis.

By fluoroscopy, pulsations were visible in the ascending portion of the aorta but not in the descending portion. I am not sure about the importance of that difference. I think that normally one sees pulsation more readily in the ascending portion of the aorta than in the descending.

Dr. George W. Holmes: I have selected some of the films that looked rather significant. This film, taken in 1940, shows hypertensive changes, a tortuous aorta and a round left border of the heart, which usually means hypertrophy of the left ventricle. It also shows rather bright lung fields, with a low diaphragm. In the oblique view, one can distinctly see the outline of the aorta; there is a good deal of magnification in this position, and the estimate of size is not too accurate. I can safely say that the patient had some dilatation of the aorta, not saccular or anything that one might interpret as an aneurysm. An abdominal film taken at that time shows part of the liver quite well, and I think that he had an enlarged liver. I cannot see anything definite in the gastrointestinal tract, and I judge from the report that it was negative. In

the 1944 films there is a marked change in the size of the heart but not in the shape. The aorta appears much as it did before: there is unusual tortuosity with some widening. I do not recall having seen many cases of hypertensive heart disease with such a large aorta. Also, it is wider in one place than in others.

DR. WHITE: The second admission was four years later. Nocturnal dyspnea appeared and increased, apparently the beginning of left ventricular failure in hypertensive heart disease. It is characteristic for these patients to have insomnia from pulmonary congestion, a point often overlooked. It might be well to point out that he still had a moderate degree of hypertension while in bed. I do not believe that we can use the blood pressure readily in differential diagnosis. A number of patients even with acute myocardial infarction have a higher blood pressure during pain than at any other time of their lives.

The red cells in the urinary sediment indicate either congestive heart failure or hypertensive renal involvement, or both.

The Hinton test was negative. They were looking hard for aortic dilatation with reference to syphilis. A gastrointestinal series showed marked tortuosity of the esophagus, apparently due to "adhesions of the esophagus to the arch." I am not familiar with that point. It is very interesting and one wonders whether it was due to aortic disease or to some mediastinal involvement.

DR. HOLMES: Tortuosity of the esophagus is not uncommon in elderly people. It does occur in some cases of chronic mediastinitis.

DR. WHITE: An inverted T_1 may be found in the electrocardiogram with either chronic hypertension or coronary heart disease. It does not necessarily mean coronary heart disease as we once thought it did. The sagging could have been the result of a digitalis effect. We do not know whether he had received digitalis before, but the patient was getting 0.1 gm. daily shortly after he had presumably been digitalized.

There was an interval of sixteen days between the two gastrointestinal series. Could the crater of a duodenal ulcer have completely healed in that short time? Perhaps one report or the other is in error.

DR. HOLMES: I think healing could have taken place in that length of time.

DR. WHITE: If he had had a duodenal ulcer could it have produced his symptoms? Not necessarily, nor his earlier ones either. I have no idea why he had abdominal pain unless perhaps it was from liver engorgement, spoken of later, which can sometimes give rise to pain in such a low position. The blood pressure was dropping, likely associated with a higher degree of heart failure.

The fluids were limited to 2000 cc. daily; 1500 cc. might have been better.

He was started on 5 drops of a saturated solution of potassium iodide. Why?

He did not die immediately, and death was not due to angina pectoris. There may have been an acute coronary occlusion, or ventricular tachycardia, or further dissection of the aortic wall, with rupture. I do not believe that a definite answer is possible concerning the exact nature of the final episode.

As for the final diagnosis, the patient certainly had hypertensive heart disease, with a big left ventricle and congestive heart failure. A healed dissecting aneurysm of the entire descending aorta with perforation into one of the iliac arteries, four years old, is quite probable, although it is almost too good a diagnosis to be true. A chronic double-barreled aorta is thought to be an extremely rare condition, but it was found in more than a quarter of Shennan's* 300 cases of dissecting aortic aneurysm, that is, a healed dissecting process with a double aorta. A duodenal ulcer, healed or healing, and terminal aortic rupture are also probable.

DR. J. H. MEANS: I can answer Dr. White's question about the potassium iodide. This man had staring eyes, lid lag and so on, and we wondered if, in addition to the rest of the picture, he had thyrotoxicosis. We thought it best to find out what his basal metabolic rate was. It was not diagnostic, but I thought it would do no harm to give potassium iodide on the possibility that he had thyrotoxicosis.

DR. CHESTER M. JONES: I should like to ask whether there is any evidence that potassium iodide is of value in the treatment of hypertension.

DR. WHITE: I believe not.

I should like to ask Dr. Allen to comment on the diagnosis of an acute abdominal emergency at the time of the first admission.

DR. ARTHUR W. ALLEN: I saw this patient in consultation at the time of the first admission, and I am afraid that I contributed little, aside from the fact that, to my mind, the case did not represent an acute abdominal emergency. I hazarded a possible diagnosis, which finally proved to be partially correct, and I also seriously considered the question of perforated ulcer. I do not recall all the physical findings, but I did not believe that the abdomen was boardlike enough to justify the diagnosis.

While I am speaking of this, I should like to ask whether the pain in the right lower quadrant could have had any bearing on the establishment of decompression of the aneurysm. If he had a fistula of the iliac artery, could that have been the cause of the pain in the right lower quadrant?

DR. WHITE: A dissecting aortic aneurysm, if that is the situation here, can explain almost any kind of pain because of the multiplicity of the vessels that can be involved. When this patient was first examined, however, he had a good femoral pulse.

*Shennan, T. *Dissecting Aneurysms.* Medical Research Council, Special Report Series, No. 193. London: His Majesty's Stationery Office, 1934.

DR. ALLEN: So he did; but they do not mention it afterward. Did it have any bearing, Dr. Jones?

DR. JONES: It is entirely possible that the pain was vascular in origin.

DR. WHITE: Does one get such diffuse pain in cases of mesenteric embolism?

DR. ALLEN: Yes, I believe he would.

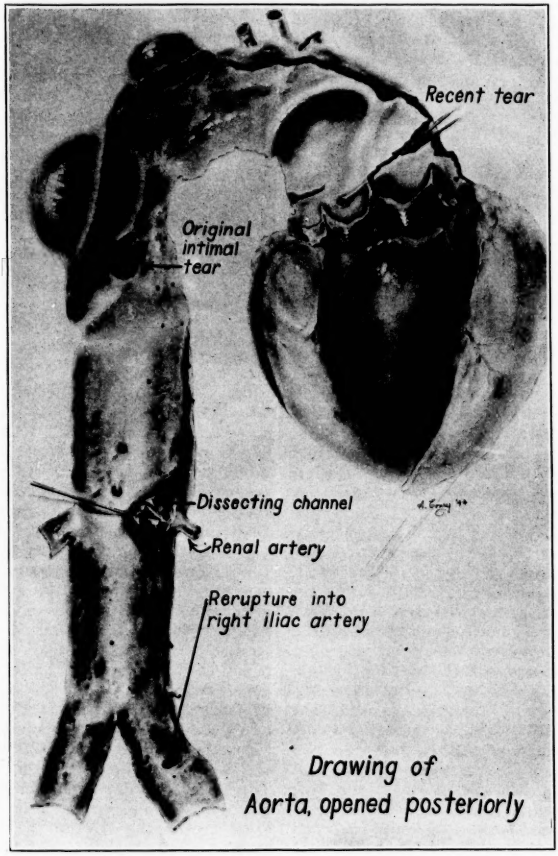

FIGURE 3.

DR. ALLEN: The pain of mesenteric thrombosis is a little different in distribution as a rule. This pain was between the shoulder blades, which is a peculiar place to get pain caused by mesenteric thrombosis. If one is suspicious of that diagnosis, more is learned by the examination of the abdomen. Although it was considered in the differential diagnosis, we did not believe that he had mesenteric thrombosis.

DR. WHITE: I suppose that he would have had more abdominal evidence.

DR. ALLEN: Yes, I believe he would.

CLINICAL DIAGNOSES

Hypertensive heart disease.
Dilated aorta (?dissecting aneurysm of aorta).
Duodenal ulcer.
Thyrotoxicosis?

Dr. White's Diagnoses

Hypertensive heart disease, with left ventricular enlargement.
Congestive heart failure.
Healed dissecting aneurysm of aorta.
Peptic ulcer?
Terminal rupture of aorta, with further dissection?

Anatomical Diagnoses

Dissecting aneurysm of ascending aorta, recent.
Dissecting aneurysm of descending thoracic aorta, healed, with rupture into right iliac artery.
Cardiac hypertrophy, hypertensive type.
Hydrothorax, bilateral.

Pathological Discussion

Dr. Castleman: The autopsy showed a hypertensive heart weighing over 800 gm. and there was about 600 cc. of clear, straw-colored fluid in each pleural cavity.

In the first portion of the descending thoracic aorta we found a large hole in the intima, which was smooth and shiny, certainly not ragged (Fig. 3). This communicated with a dissecting channel that went all the way down the aorta and re-entered the original stream at the origin of the right iliac artery, as Dr. White predicted. Here also the edges of the opening were smooth and shiny, indicating that the process was not recent. This old dissecting aneurysm had developed a new intimal lining, on top of which arteriosclerosis had been superimposed. Apparently the initial intimal tear, which occurred presumably in 1940, produced the bulging aneurysmal sac that was seen in the x-ray films. This aneurysm, which at first glance looked like the ordinary syphilitic aneurysm, was filled with a laminated thrombus, all of which was within the media and part of the dissecting process.

Just beyond the arch was another smaller but similar bulge, which also had an intimal opening. There was no communication between the two at the time of autopsy, and neither of them had ruptured externally. The dissecting aneurysmal sac had dissected around the mouths of the renal, intercostal and inferior mesenteric arteries and had lifted up the intima to produce some narrowing. There was, however, no dissection along these arteries.

The terminal event was an acute dissection of the aorta in the ascending portion, which is the commonest location. The intimal tear was transverse and was located just above the valve. It had dissected distally to include the arch and proximally as far as both coronary mouths. There was no external perforation, so that the sudden death may have been anginal, owing to constriction of the coronary orifices.

Dr. Means: I should like to ask Dr. White and Dr. Castleman if they think that the administration of iodide contributed to death by softening the aorta.

Dr. Castleman: I doubt it.

Dr. White: So do I.

I should again like to call attention to the monograph written ten years ago by Dr. Shennan, of London. He reported 300 cases, 79 of which were old healed aneurysms. I looked them up last night because I was interested in how the patients died. I found a variety of ways, but most of them died of heart failure.

Dr. Allen: Did any die because a surgeon tried to establish an iliac opening?

Dr. Castleman: That has been tried in New York. The man lived a week.

Dr. Means: What do you think the course of the blood was after this first aneurysm had taken place? Was the aneurysm acting as a channel as well as the aorta?

Dr. Castleman: Without any question, but the aneurysm was small.

CASE 30342

Presentation of Case

A sixty-four-year-old woman, a domestic, was brought into the hospital in semicoma.

The patient was known to have had high blood pressure (230 systolic, 100 diastolic), an enlarged heart and a more or less chronic cough for several years. She had had dyspnea on exertion for the ten months before entry, during which period she had received 0.1 gm. (1½ gr.) of digitalis three times a day for one week, followed by 0.1 gm. daily. She was well except for occasional episodes of upper respiratory infection and cough. About seven months before entry, after one of these episodes of upper respiratory infection, cough and dyspnea, she was examined in the Out Patient Department, where x-ray films showed no unusual findings except for an enlarged heart. She was treated for cough and continued to receive 0.1 gm. of digitalis daily. Three weeks before entry, following another attack of upper respiratory infection in which she experienced considerable dyspnea, a feeling of extreme weakness, and cough productive of white phlegm, she was again seen in the clinic, where examination showed diminished breath sounds over the right lower lung field, with occasional expiratory squeaks. At that time the blood pressure was 220 systolic, 100 diastolic. The temperature was 99°F.; the pulse was 84 and regular. X-ray examination of the chest showed extensive increased density along the right border of the lung parallel to the diaphragm, and reaching from the lower aspect of the hilus almost to

the axillary line (Fig. 1). There was no hydrothorax. She improved in the next few days, but a repeat x-ray examination of the chest five days later showed little change in the appearance of the lungs. The density in the right lower lung field appeared to be confined to the right middle lobe. The trachea was extremely narrow, which had apparently been noted on one or more previous examinations. Flecky calcification was seen over the dome of the right diaphragm. The left costophrenic angle was obliterated. The improvement continued until seven days before entry, when she had a sudden attack of sharp pain in the right chest without fever or chills. She had a feeling of fullness in the pit of the stomach but no nausea or vomiting. The pain was relieved by the application of heat. She visited the clinic two days later, but refused hospitalization and returned home. She apparently stayed in bed, without eating or drinking much, gradually became disoriented and was found in a state of semicoma. She was then admitted to the hospital.

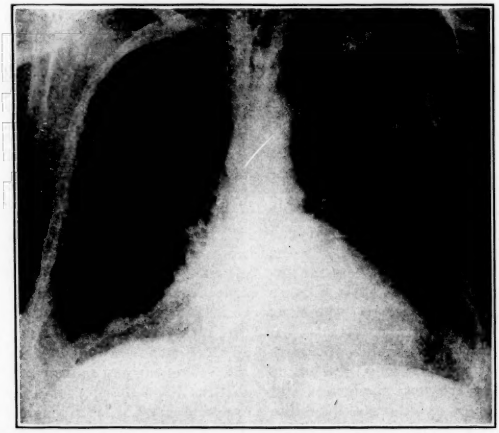

FIGURE 1.

Four years before admission she had been treated for pernicious anemia. During that period she was discovered to have positive blood Hinton and Wassermann tests. About eighteen months before admission the spinal fluid was negative. She had had no history of primary or secondary manifestations of syphilis, and no treatment was given.

Physical examination showed a thin, poorly nourished, semicomatose woman. The skin was moist and warm. The pupils were round, regular and pinpoint, and did not react to light or accommodation. The extraocular movements were normal. The tongue was dry, rough and red. The neck was stiff. The chest was barrel shaped. Over the right base posteriorly there was dullness, with bronchial breathing, diminished tactile and vocal fremitus and many rhonchi and rales. The left border of cardiac dullness was 8.5 cm. to the left in the fifth space. A Grade II apical systolic murmur was heard over the precordium but was not transmitted. The abdomen was mildly distended with gas. Some voluntary and involuntary generalized spasm was present. Peristalsis was diminished, and there was some tinkling of the peristaltic sounds. Considerable mottling and cyanosis of the feet and fingers were noted. Neurologic examination revealed a right facial paralysis. The tendon reflexes of the left arm were more active than those of the opposite arm or of the legs; the plantar reflexes were normal.

The blood pressure was 180 systolic, 84 diastolic. The temperature was 99.2°F., the pulse 100, and the respirations 24.

Examination of the blood showed a red-cell count of 3,620,000, with 14.6 gm. of hemoglobin. The white-cell count was 23,800 with 98 per cent neutrophils. The urine specific gravity was 1.016, and the reaction pH 4.5; it gave a + + + test for diacetic acid.

The patient was placed in an oxygen tent and given 10 cc. of aminophyllin intravenously and 500 cc. of 5 per cent glucose in physiologic saline solution. She died nine hours after admission.

Differential Diagnosis

Dr. Helen Pittman: This woman had a great many things the matter with her, and the first point is to try to decide which are relevant to the terminal illness. She had apparently been treated for pernicious anemia four years before. I do not believe that that had much to do with the last episode. She was known to have positive blood tests for syphilis four years before, but a spinal-fluid tap eighteen months before entry was negative, and so long as she had no history of primary or secondary manifestations of syphilis and no treatment given, it is probably safe to assume that the pupils were not pinpoint and did not fail to react at that time. Discarding these things, we come to the final illness. She had been known to be hypertensive, with a large heart and more or less chronic cough, for a good many years. She had been ill for three weeks but had been well enough to come into the Out Patient Department and well enough to refuse hospitalization a week before she was brought in semicomatose to die in nine hours.

I am particularly anxious to see the x-ray films because apparently we can assume that the lung fields were negative until three months before the present illness, despite the fact that she had had a chronic cough for a good many years.

Dr. George W. Holmes: The diaphragm is high and the heart lies more or less horizontally in the chest, which tends to increase the size of its shadow regardless of the size of the heart. On the other hand, the curve of the left ventricle is prominent and enlargement is definite. In the lateral view the anteroposterior diameter of the chest is obviously increased, and the patient probably had some emphysema. Except for the low diaphragm and the absence of limitation of movements this is the type of chest that one sees in asthmatics.

In the area along the right border of the heart there is a definite change. From a right border well within normal limits in the first film, there is in the later film an indefinite hazy shadow that spreads out along the level of the diaphragm. In the lateral view this shadow lies in the anterior part of the chest and is thus in the region of the middle lobe. The other shadow, which extends along the axillary border, makes one suspect that fluid was present.

Dr. Pittman: What do you think about the size of the lobe? Is it normal?

Dr. Holmes: There is little evidence of collapse. The diaphragm is not in the usual position. The heart, if anything, is away from the lesion rather than toward it, and there is no increased aeration in the portion of the lung above it, which ought to occur. I do not believe that there is any definite evidence of bronchial obstruction.

Dr. Pittman: Do you see anything in the oblique view that you could possibly interpret as a cavity?

Dr. Holmes: The details do not show up well in this light, but there is no definite evidence of a cavity. There are areas of calcification; I do not know what they are, and they are probably of no importance.

Dr. Pittman: Do these shadows indicate dilated bronchi?

Dr. Holmes: I should not care to commit myself.

Dr. Pittman: This is one of the times when the description of the films adds little to the description previously given. The question is, Which set of systems are we going to blame for this woman's final illness? She had a middle-lobe process. We have seen a great many middle-lobe pneumonias this year, but the patients either have recovered or still have something going on in the middle lobe without serious trouble.

This woman had a three-week illness, and we are told that she had an x-ray film taken seven months before entry that was essentially normal. The dry, rough, red tongue was, I assume, the tongue of dehydration, malnutrition and avitaminosis. I do not believe that it was the tongue of pernicious anemia. The blood pressure apparently dropped a good deal, which is not surprising. The patient entered the hospital semicomatose, with small pupils that did not react, a stiff neck and right facial paralysis, and these rather impressive signs point to something in the central nervous system. She had slight fever, and the pulse and respirations were only slightly elevated. She had a definitely elevated white-cell count — 23,000, with 98 per cent neutrophils. The urinary findings I attribute to her nutritional state. The process in the chest was rather extensive, and yet I do not recall that any comment was made about cough or whether she was raising any sputum at the time of admission. With as much of a process in the chest I should have expected her to have cough and to be producing sputum. If sputum was not being raised because of bronchial plugging, I should have expected an elevation of temperature comparable to the leukocytosis of the blood.

So we come down to trying to decide whether this woman's terminal episode, which I am quite sure was cerebral, was on a vascular basis in a patient with known hypertension of many years' duration or due to infection. Whether she had a cerebral hemorrhage accompanying this pulmonary process or whether the terminal lesion was on some other basis, I do not know. I tried to see if I could get any leads from Dr. Holmes that would give a reasonably good cause for postulating a lung abscess. The chest was clear enough six months after entry to make us reasonably sure she did not have a long-standing bronchiectasis. We do know that one of the dangerous complications of lung abscess is cerebral metastasis and that this is one of the most frequent causes of death in such cases. Here, however, we have slim evidence on which to make a diagnosis of lung abscess. There was a definite process in the chest, which did not shrink the lung.

The lobe was not smaller than normal, and even though no fever and cough are mentioned in the record, I think that they were overlooked. A white-cell count of 23,000 and 98 per cent neutrophils are definite signs of infection. I am no neurologist but I looked up a few things and believe that the cranial-nerve signs on one side and the hemiplegia on the opposite side, the contracted, rigid pupils and the stiff neck are consistent with a lesion in the pontine area. Therefore I am going to say that this woman had a pneumonia of the right middle lobe, and that she developed suppuration in that lobe and that she died of a metastatic brain abscess in the pontine region.

DR. FREDERICH KLEMPERER: I followed this patient for the three years before entry. When I first saw her she was being treated for pernicious anemia and syphilis. It is questionable whether she ever had pernicious anemia because when specific treatment was discontinued the red-cell count did not come down; in fact she had not received liver extract for three years. Antisyphilitic treatment was discontinued because of her generally poor condition — the marked hypertension and the fact that she was in and out of mild cardiac failure. The spinal fluid was negative. She had some neurologic signs — absent knee jerks and markedly diminished ankle jerks. She complained about paresthesias in the legs, but sensory examination was negative. The neurologic findings have never been explained.

I last saw her about ten days before she died, when she gave a story of cough and malaise, which had markedly improved by that time. X-ray examination was said to have shown atelectasis of the lower lobe, and I urged her to enter the hospital, but she refused. My impression was that she had either pneumonia or infarct and that the prognosis was poor.

DR. J. H. MEANS: Was a lumbar puncture done?

DR. KLEMPERER: Not at that time; the one done two years before was negative.

DR. MEANS: Did she have a positive Kernig sign as well as a stiff neck?

DR. KLEMPERER: Not so far as I know.

DR. MEANS: I suppose that the final episode was not related to the pulmonary situation. She may have had some kind of subarachnoid hemorrhage.

CLINICAL DIAGNOSES

Bronchiogenic carcinoma?
Bronchopneumonia?
Cerebral hemorrhage.

DR. PITTMAN'S DIAGNOSES

Pneumonia, right middle lobe, with suppuration.
Metastatic brain abscess (pontine).

ANATOMICAL DIAGNOSES

Lobar pneumonia, right middle lobe (pneumococcus, Type 14).
Empyema (pneumococcus, Type 14).
Bacteremia (pneumococcus, Type 14).
Cerebral thrombosis, recent: left internal carotid artery.
Syphilitic aortitis.

PATHOLOGICAL DISCUSSION

DR. CASTLEMAN: The autopsy on this patient showed an extensive empyema in the right chest, limited almost entirely to the region of the lower lobe. After the pus was aspirated we found that the middle lobe was completely solid. On section it showed the characteristic gray hepatization of lobar pneumonia. This process had extended partly into the right lower lobe; the lower portion of the lower lobe was not involved but was collapsed.

Microscopic examination showed a process that I do not believe could have been three weeks old; it probably began when she complained of pain in the chest about a week before she entered the hospital. What the process was at the time of the second x-ray film I cannot be sure. She may well have had an acute bronchitis with some atelectasis in the region in which the lobar pneumonia subsequently developed. We were able to recover a Type 14 pneumococcus from the pleural pus and the blood.

In the brain we found a fresh thrombus in the left internal carotid artery, with early softening of the cerebral hemisphere on that side. The bone marrow showed hyperplasia of the myeloid elements but no evidence of red-cell hyperplasia, so I think that we can rule out pernicious anemia.

She did have evidence of syphilis in that we found a mild aortitis with some narrowing of the coronary mouths.

DR. HOLMES: Was the trachea narrowed?

DR. CASTLEMAN: Yes, but we could not determine the cause; perhaps it was congenital.

DR. MEANS: Could you connect the cerebral and pulmonary affairs?

DR. CASTLEMAN: There was no infection in the brain.

DR. HOLMES: In the last film there is some evidence of fluid in the pleural space, but nothing like what you describe.

DR. CASTLEMAN: That film was taken the day before death. The empyema must have been present for at least three or four days, if not longer.

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PREPAID MEDICAL CARE A LA KAISER

The Permanente Foundation Hospital has recently published its first annual report.* Starting with 6 physicians and 6 nurses on March 1, 1942, it opened offices in Oakland, California, and began to render industrial medical care to 20,000 men of two of the Kaiser shipyards. By the end of February, 1943, it was serving 90,000 workers and comprised a staff of 62 doctors, 241 nurses and 324 miscellaneous employees. It then had available 209 hospital beds, and construction of a 100-bed addition was begun later in the year. Three issues of the *Permanente Foundation Bulletin*, which contain eighteen papers reporting clinical experience at the hospital by members of its staff, had already been published, and many other articles have appeared in various medical journals. These indicate a high standard of medical practice.

Some of the features of the report are worthy of study by all those interested in improving the standards of medical care and in providing it at a low cost to low-income and moderate-income groups. The history of the Permanente Foundation, its relations with the local medical profession, its financial statement and the medical services that it offers are reported in some detail. Some excerpts are as follows:

> Our medical service and the Foundation were necessitated by the same motivating force that created the medical program for the armed services. That force was the dislocation of masses of people to areas where existing medical and hospital services were inadequate.
>
> We find that, where production for war created tremendous shifts in population, in the majority of instances medical and hospital care for these people was entirely forgotten. This was not so, however, where the armed forces directly entered production; for example, in Navy shipbuilding yards, Navy physicians, in uniform, were responsible for the care of the workers' health. When private industry was given the job, no such care was provided.
>
> The Kaiser organization had . . . a knowledge acquired from past experience in providing medical and hospital care in industry. . . . [It] had been engaged prior to the war in building huge construction projects in isolated areas, such as Coulee Dam. With no pre-existing medical and hospital facilities available, these had to be provided to the many people employed. By trial and error, a method of highly satisfactory service was worked out through the years. After Pearl Harbor when the influx of war workers into the Richmond-Oakland area created a similar lack of hospital and medical facilities, it was evident that the tested solution which experience and time had proven efficient should be put into effect.
>
> As a result Permanente Foundation was born. A charitable trust, with a Board of Trustees, headed by Mr. and Mrs. Henry J. Kaiser, registered in Alameda County, California, was set up in such a manner that there would be no profit incurred by anyone in the Kaiser organization. Any funds that may be accumulated by the Foundation must be used only for such charitable purposes as: medical research, provision of facilities in needy areas, medical care for the poor, rehabilitation of men returning from the war and so forth.

Economically, the results have been rather amazing. In spite of wartime difficulties, with the associated high cost of supplies and high salaries, while receiving only pre-war income from the employees, the Foundation has accomplished the following: retired $500,000 of the debt of $700,000

*Garfield, S. R. First annual report of the Permanente Foundation Hospital. *Permanente Found. Bull.* 2: 35-48, 1944.

incurred in building and equipping its hospitals; paid physicians' salaries ranging from $4800 to $14,000 and totaling $500,000 per year; paid a similar total to staff nurses at the rate of $150 to $200 a month; provided the health-plan members with one of the most comprehensive coverages ever attempted; and treated a group of people definitely below par physically. No physical examinations were possible under union contract, but even if permitted, the shipyards would have been forced to employ practically all these workers because of the shortage of manpower.

The report goes on to mention the distrust with which the medical profession first looked on this financial plan. Gradually the profession became more tolerant as they recognized the tremendous load that the organization was carrying and the extraordinary conditions under which its job was being done.

The author of the report also goes on to discuss the future of the organization and the factors on which its continued existence must depend. The advantages to the workers and to the physicians of maintaining this or a similar medical service are enumerated. Details are also given concerning the quantity and quality of medical care furnished during the period covered by the report.

This report makes impressive reading and warrants more than a glance by physicians who are interested in the socioeconomic aspects of medical practice. Those who are now actively concerned with the problems of prepaid health and medical-care insurance may find it useful to adopt some of these methods and principles in order to obtain the most effective and efficient medical service to large numbers of people at low cost—and at the same time to maintain the high standards and dignity of the medical profession.

The conditions that make possible the establishment and maintenance of such an organization, however, appear to be comparable to those that occur in the Army and the Navy; that is, a large number of people in relatively good financial standing are herded into a new environment. What will happen when this wartime industry is disbanded or decentralized? How can this type of service be adapted to communities where reasonably adequate medical and hospital facilities already exist, where many of the inhabitants seek hospitalization in terms of race and religion as well as medical competence and where they are working under the usual ups and downs that characterize small or moderate-sized industries? Can established practitioners and specialists adapt themselves to this type of medical care without serious disruption of such services? These are merely a few of the problems involved in adapting the Permanente setup to the one hundred and thirty million people of this country and to the doctors who must serve them.

SUTURE MATERIALS

Over fifty years ago Halsted[1] described the fine silk suture technic in clean surgical operations and attested to its safety and efficacy. The method was accepted by few surgeons at that time, probably because it entailed such painstaking procedures and was so time consuming. Through the influence of Halsted's many pupils, however, as they scattered through the country and undertook important responsibilities, the technic gradually spread so that after forty years there were many nuclei, particularly in the teaching institutions, where this method of suturing was exactly carried out. At about that time the meticulous experimental work of Howes and Harvey[2] showed that catgut sutures, as they were then made and used, frequently disintegrated before the sutured tissues had gained any appreciable tensile strength through the processes of repair. In spite of this, catgut still continued to be used in the vast bulk of surgical practice.

Four years ago, Meade and Ochsner[3] demonstrated that fine cotton sutures could be used in the same way that fine silk sutures had been used, and with equally good or better results. They also showed that the "lag period" in healing was reduced and that there was no period subsequent to suture when a wound in a healthy animal, correctly sutured with cotton, was any weaker than it was when the sutures were first placed. They also demonstrated that, even if a wound sutured in this way became infected, a permanent draining fistula associated with infection about the knots did not necessarily result, provided the cotton was not used for a continuous suture and provided that extremely fine

material with tiny knots accurately placed on small pieces of tissue was employed. These, of course, are the same criteria that Halsted set up for success with silk over fifty years ago.

Another defect of catgut was brought to light last year, when Dunham and Jenkins[4, 5] showed that the tubing fluids with which most forms of catgut are impregnated contain highly irritating substances, which delay the process of repair.

A large dealer in surgical supplies has recently stated that the sales of silk and cotton for surgical use are rising by leaps and bounds and that the sale of catgut is stationary. Because of the fact that much of the silk and cotton for surgical use is bought through department stores, this statement assumes great significance. Of course, the manufacturers of catgut are improving their product, and catgut has a place in surgery, even in the work of those who are most enthusiastic in the use of nonabsorbable material. Such operations as those for hemorrhoids and for various types of gross infection will continue to need catgut, perhaps forever. Also, nonabsorbable sutures should never be buried in long strands, which means, for example, that the continuous suture used in the first layer for repair of the peritoneum should be made of catgut.

Any surgeon worthy of the profession should pride himself on his manual dexterity, and any busy surgeon with average dexterity, provided he is willing to devote a little care and thought, can quickly learn to use fine silk or fine cotton. The time may well be approaching when the use of catgut in routine operations will be the mark of a habit-bound surgeon.

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MASSACHUSETTS MEDICAL SOCIETY

DEATHS

BLANCHETTE — William H. Blanchette, M.D., of Fall River, died August 1. He was in his seventy-second year.

Dr. Blanchette received his degree from Baltimore Medical College in 1896. He was a member of the American Medical Association.

HEAVEY — Thomas J. Heavey, M.D., of Medway, died August 7. He was in his fifty-ninth year.

Dr. Heavey received his degree from the Middlesex University School of Medicine, Waltham, in 1922. He was a member of the American Medical Association.

KICKHAM — Edward L. Kickham, M.D., of Brookline, died August 10. He was in his forty-ninth year.

Dr. Kickham received his degree from Tufts College Medical School in 1923. He was a member of the obstetric and gynecologic staff of the Carney Hospital and St. Elizabeth's Hospital, having been associated with the former since 1924 and with the latter since 1930. He had been instructor in gynecology at Tufts College Medical School since 1930. He was a fellow of the American College of Surgeons and the New England Obstetrical and Gynecological Society and a member of the American Medical Association, the American Board of Obstetrics and Gynecology and the Boston Obstetrical Society. He was treasurer of St. Luke's Guild of Boston.

His widow, two brothers and a sister survive.

WAR ACTIVITIES

INDUSTRIAL HYGIENE

Chlorine Gas Hazards in Aluminum Foundries

The chlorine hazards in aluminum foundries have been shown by a study made in California to be threefold:

Aluminum readily combines with the oxygen in water, releasing hydrogen gas, which collects in the interstices or porosities of aluminum in the melting pot. This gas is generally removed by passing chlorine through the molten metal so that the hydrogen combines with the chlorine to form hydrochloric acid. The excess chlorine is discharged into the atmosphere above the melting pot, unless removed by an exhaust hood, but the hood must be properly designed, or only a portion of the gas is removed.

The chlorine gas is introduced into the bottom of the melting pot by pipes connected to the tanks by short lengths of rubber hose. These pipes may become clogged as the chlorine tanks are moved from pot to pot. As the full tank pressure may exceed 100 pounds per square inch, the rubber hose may leak or burst. Moreover, a chlorine tank may burst from overheating or from being tipped over, causing a fatality.

Gas burners under the melting pot are frequently unvented, so that carbon monoxide concentrations may be as high as 50 to 75 parts per million and, as phosgene is readily formed from a combination of carbon monoxide and chlorine, there is danger of both carbon monoxide and phosgene poisoning.

Proper protection of the workmen requires a rather complicated system of control, consisting of venting of all gas-burning devices, as well as much greater supervision of the method in which chlorine is handled. — Reprinted from *Industrial Hygiene News Letter* (July, 1944).

MISCELLANY

NOTE

The Hercules Powder Company has inaugurated educational tours to acquaint local physicians with working conditions to which their patients may be exposed. The first tour was made in Mansfield and attended by local physicians, representatives of the Massachusetts Division of Occupational Hygiene and the Committee on Industrial Health of the Massachusetts Medical Society.

TUBERCULOSIS IN SCHOOLS

The protection and education of children is universally conceded to be one of the primary functions of the modern state. In the realm of public health, especially that part which concerns itself with the control of tuberculosis, this

function has been translated into the well-accepted principle that no person with positive sputum should be allowed to remain in a household where there are children. Too long, however, the danger of tuberculosis among school personnel has been overlooked although the school ranks immediately after the home in importance in the life of a child. The following statements, abstracted respectively from two recent publications (Laberge, L. Detection of tuberculosis in schoolteachers in the Province of Quebec. *Canad. Pub. Health J.* **34**:125-129, 1943 and *Tuberculosis Control in the Schools of New Jersey.* Compiled by the New Jersey Tuberculosis League, co-operating with the State Department of Public Instruction, January, 1944) emphasize the problem.

* * *

The Legislative Assembly of the Province of Quebec on May 17, 1941, unanimously passed an act stating that no person can teach in a public, private or independent school unless he produces every year a physician's certificate stating that he "suffers from no infirmity or disease which renders him unfit for teaching" and "a certificate from a phthisiologist attesting that a clinical and radiological pulmonary examination shows that such person is free from tuberculous disease." Such examination must be made within two months following the engagement. Should any teacher prove to be tuberculous the contract to teach is immediately rescinded.

If Quebec glories in being the first province in Canada to pass such a law it must be admitted that it is the one to need it most — having the highest death rate from tuberculosis among the Canadian provinces. Three factors led to the passage of the law. First, a three-year educational campaign on tuberculosis that reached most of the population; second, a law passed by the City of Quebec requiring all teachers of the School Commission to undergo examination for tuberculosis, including films of the chest (out of 523 teachers examined 16 were withdrawn from teaching because of active or chronic tuberculosis). The third factor was a personal experience published in an educational review, which demonstrated mass contamination of pupils by a tuberculous teacher.

The legislation was introduced by the Council of Education, of which all the bishops of the province are members, so the doors of the teaching religious congregations were thrown open.

Difficulties arose in the enforcement of this new law as was to be expected, but these were overcome as the organization proceeded. In rural districts the expense was borne by the Board of Health, and in Montreal the Catholic and Protestant school commissions paid for the x-ray films.

The results of the examination of 16,524 teachers in the Province of Quebec, with the exception of the City of Montreal, are shown in Table 1.

It is apparent that tuberculosis was twice as prevalent among religious teachers as it was among the lay teachers, even though most of the religious congregations have required, for the past few years, an x-ray examination of the chest from all applicants for admission to their groups.

TABLE 1. *Examination of Schoolteachers for Tuberculosis (Province of Quebec except City of Montreal).*

Type of Teacher	No. Examined		Rejected for Tuberculosis No.		Percentage
Female:		13,553		178	1.3
Religious	6,152		115	1.9	
Lay	7,401		63	0.9	
Male:		2,971		34	1.1
Religious	2,155		27	1.3	
Lay	816		7	0.9	
Totals		16,524		212	
Average					1.3

In the City of Montreal, the results of examination for tuberculosis do not show the same trend. According to Dr. Laberge, the report was not complete for the religious teachers. The data from the Catholic School Commission are summarized in Table 2. The Protestant School Commission reported 1533 teachers x-rayed, only 1 of whom was rejected.

* * *

During August, 1939, an act passed by the Senate and General Assembly of New Jersey provided that the board of education of every school district should periodically determine the presence or absence of active tuberculosis in any or all pupils in public schools. The rules and regulations for complying with this were to be made by the State Board of Education. Any pupil found with active tuberculosis was to be excluded from school until the disease was no longer communicable. Employees (which include teachers) of boards of education were required to have a physical examination by the provisions of a similar act passed at the same time. The State Board of Education was to determine the scope of such an examination.

The State Board of Education on May 11, 1940, ruled that all pupils of grades nine, ten, eleven and twelve and all special students enrolled in high school should be listed or examined annually, as early as possible in each school year. For employees the board ruled that the examination was to be limited to determination of the presence or absence of tuberculosis.

TABLE 2. *Examination of Schoolteachers for Tuberculosis (City of Montreal — Catholic School Commission).*

Type of Teacher	No. Examined		Rejected for Tuberculosis No.		Percentage
Female:		2,785		9	0.32
Religious	1,879		3	0.16	
Lay	906		6	0.66	
Male:		1,910		6	0.31
Religious	762		0	0.00	
Lay	1,148		6	0.52	
Totals		4,695		15	
Average					0.32

This legislation was the climax of a long-term program of health education in homes, schools and community groups in New Jersey. Parents, children and school personnel were ready for the step when it was taken so there was no serious opposition in any county. The examinations themselves were used as an educational demonstration, and great care was taken to prepare pupils for them. It is now recommended that discussion with pupils should follow the testing. Answering students' questions and explaining the results in classrooms or individually will do much to give the procedure meaning.

X-ray examinations of the students who were positive reactors, and of a few students who were not tuberculin tested, revealed 343 cases of reinfection type tuberculosis or approximately 2 per 1000. Of the 2772 teachers examined, 67, or 2.4 per cent, had reinfection tuberculosis. Of these, 31 were classified as stable.

Reports on the disposition of reinfection type tuberculosis were incomplete. However, 23 patients were hospitalized, 21 were excluded from schools, 2 died shortly after examination and 40 students and employees were permitted to return to school under medical supervision with periodic x-ray examination.

Out of 195,130 students in New Jersey schools during 1941–1942, 19.9 per cent were positive reactors to the tuberculin test. Of 59,736 who were tested for the first time, 13.8 per cent were positive reactors. Retests of 99,964 students who were negative reactors in previous years yielded 10.7 per cent positive reactors. This group is highly significant from the standpoint of epidemiologic control. Its members have been recently in contact with an infection source. The prevailing infection rate in the school population therefore is slightly less than 20 per cent. Among teacher and employee group 39.7 per cent were positive reactors. Other significant chest, heart and orthopedic conditions were revealed by the school tuberculin testing and x-raying program. — Reprinted from *Tuberculosis Abstracts* (September, 1944).

BOOK REVIEW

A Catalogue of the Medieval and Renaissance Manuscripts in the Boston Medical Library. Compiled by James F. Ballard, director, Boston Medical Library. Sm. fol., 246 pp. Boston: privately printed, 1944.

The first impression in looking through the Boston Medical Library's new catalogue of incunabula and early manuscripts is that the volume has been planned — as every catalogue should be planned — to contain everything that

one needs and nothing more, in itself a bibliographical feat of high order. Its annotations, for instance, are a model of scholarly discrimination — brief, to the point, and present only when needed to emphasize information of importance. In addition to its seven hundred and twenty-six entries, there are three concordances and five indices. Thus it has been made not only a lean volume, but a well-rounded one.

The collection has as its purpose the gathering of such manuscripts and early printed books as might have been brought together in a fifteenth-century physician's library. Such, in fact, was the original aim of Dr. William Norton Bullard, whose collection, first through loan and then through bequest, forms the foundation upon which the library's collection rests. To his books have since been added purchases from the Bullard, the Godfrey M. Hyams and the John Warren funds, as well as from the library's general resources, with the result that the collection now totals fifty-two medieval and renaissance manuscripts, and six hundred and seventy-four early printed books.

As is to be expected, the majority of these are of medical interest. But, in rounding out the collection, the director has taken into consideration the fact that a physician of the fifteenth century no doubt had minor interests and hobbies, which would have brought books on other subjects to his shelves. For this reason, in Mr. Ballard's excellent subject-index, one finds occasional and intriguingly nonmedical books on architecture, geology, gambling, hunting, orations, inventions and canon law.

A library reproducing such a physician's interests, it seems, is not a hypothetical matter. As pointed out in Dr. Henry R. Viets's scholarly introduction to the catalogue, the manuscript collection follows closely the titles known to have been in the library of Giammatteo Ferrari da Gradi, who was professor of medicine at the University of Pavia from 1432 to 1472, as also the medical books in the scientific library brought together by Cardinal Nicolaus of Cues prior to 1464. Similarly, the fifteenth-century printed books run parallel to those known to have been in the collections of contemporary physicians, such as Hieronymus Münzer, Hartmann Schedel, Ulrich Ellenbog and Nicolaus Pol. In fact, the library actually has a number of books from Münzer's collection.

Through the medical incunabula upon the Library's shelves, it is possible to understand the status of medical science at the time of the invention of printing, "when the impounded waters of culture were let loose." Through the early manuscripts here assembled, it is possible to reconstruct the historical background upon which medical science then rested.

Collectanae Medica, a manuscript written by various physicians within the two-hundred-year period from 1250 to 1450, treats of a fascinating combination of subjects — eye and skin diseases, corns, "palsey," measles, gout, laryngitis, food and drink in relation to health and so forth. In addition, it includes a fourteenth-century prayer, written about 1350, to be pronounced by a physician when administering a remedy; and also a formula for extracting blue coloring from lapis lazuli which, interestingly enough, may have some bearing on the quality of the blue used in the beautifully illuminated borders and initial letters of the period. Another *Collectanea Medica*, written about 1450, contains treatises on the detection of disease, the plague, and the effects of the zodiac on blood-letting. A *Register Simplicium*, a manuscript of special interest, written in Austria in 1477, contains a long inventory of medieval drugs and materia medica.

On the opening page of the incunabula section of the catalogue there is an entry for the 1471 Jensen edition of Abulcasis. Bound with the library's copy of this work is Nicolaus Salernitanus's *Antidotarium* of the same press and year. Farther on in the text are noted later editions of Mesue's *Opera Medicinalia*, first printed in 1471, and of Pliny's *Historia Naturalis*, issued in 1469 and again in 1470. And prior to the Pliny came the *De Sermonum Proprietate* of Rabanus Maurus, undated but assigned to a Strassburg press before July 20, 1467. The last not only has its honored place upon the library's shelves, but it heads the list in Osler's *Incunabula Medica*, as the first medical book known to have been set in type. Thus, exclusive of single-leaf prints, the catalogue accounts for a half dozen of the first medical items known to have been circulated in printed form. And among its early broadsides, the library is fortunate in possessing the rare third *Almanac* in German, a blood-letting calendar, assigned to the Zainer press at Augsburg about 1469–1470. Although part of its second column is lacking, the only other copy of the *Almanac* that is known (in Munich) has the second column intact, but lacks part of the first. Thus, the two copies together provide the complete text.

Among the books of anatomical interest are Peyligk's *Compendium Philosophiae Naturalis*, the first printed anatomical treatise with illustrations; and Brunschwig's *Das Buch der Cirurgia*, printed at Strassburg by Grüninger in 1497. In the copy described, new matter has been added, including a brief tract on anatomy and a woodcut diagram of a skeleton. In view of the questions involved in the make-up of this variable work, it is worthy of note that the library's copy — perfect, uncolored and in prime condition — is identified in Mr. Ballard's note as follows: "The first impression of the first edition [of *Das Buch der Cirurgia*] with the first printing of the added *Anathomia* as described by Sudhoff, Arch.f.d.Gesch.d.Med., Lpz., 1907–1908, 1:41. With 48 large woodcuts printed from 18 different combined blocks, 13 small woodcut illustrations, and the full-page woodcut of the skeleton for the *Anathomia* adapted from the Helain broadside of 1493." Of even greater rarity is a broadside probably contemporary with the woodcut accompanying the *Anathomia* [early 1498?]. This represents a skeleton drawn with much artistic feeling, and engraved on copper by Zoan Andrea — a broadside of which only two other copies are known, and those both in Paris.

Six books were not registered as in the country in 1940, when the second census of incunabula in North American libraries was published. The Catalogue thus adds to our records the German *Almanac* already mentioned, a German edition of the *Ruralia Commoda* of Petrus de Crescentiis, the *Recollectae super Physica Aristotelis* of Gaietanus de Thienis, the *Lunarium* of Bernardus de Granollachs, a *Tractat contra Pestem*, attributed to Heinrich Louffenberg, and the *Prothonotariomastix* of Paulus de Middelburgo.

By the cleverly economical phrases, "not in Osler" and "not in Klebs," used advisedly with a few entries, Mr. Ballard has given passing emphasis to a score or so of titles whose interest to medical science has made them in his opinion worthy of inclusion. Among them he notes the important *Bull on Burials*, issued by Bonifacius VIII, which, in its condemnation of the dismemberment of bodies of the dead, was for a time, until its re-interpretation, accepted as opposed to dissection and hence to the acquiring of direct anatomical knowledge.

In providing a subject-index for the volume, Mr. Ballard has made a very vital and important contribution to the study of incunabula, for early printed books, like other books, were originally published because of the timeliness of their subject interest. Various bibliographers, Dr. Osler outstanding among them, have within fairly recent years segregated medical incunabula. Dr. Klebs has contributed still more to the classifying of incunabula by enlarging his survey of medical incunabula to include other sciences. But Mr. Ballard in his subject-index has broken down the broad classification into the specialized interests of the individual books. In other words, he has analyzed his incunabula just as modern books are indexed, thus making a contribution both to the study of incunabula and to the history of medicine. Here, in the catalogue of a collection brought together for the purpose of reproducing a fifteenth-century physician's library, is a subject-index of some two hundred entries. Thus the catalogue gives knowledge not only of physicians' books but of their contents as well.

It is a pleasure to find that publication of the catalogue has come at a time when Mr. James F. Ballard, director of the Boston Medical Library, has completed fifty years of service. The volume thus stands most fittingly as the culmination of his long years of scholarly labor.

It has been issued in an edition of four hundred copies, planned in an appropriate, clearcut format by Dr. Viets, the librarian, and printed by the George Banta Publishing Company of Menasha, Wisconsin.

(*Notices on page xv*)